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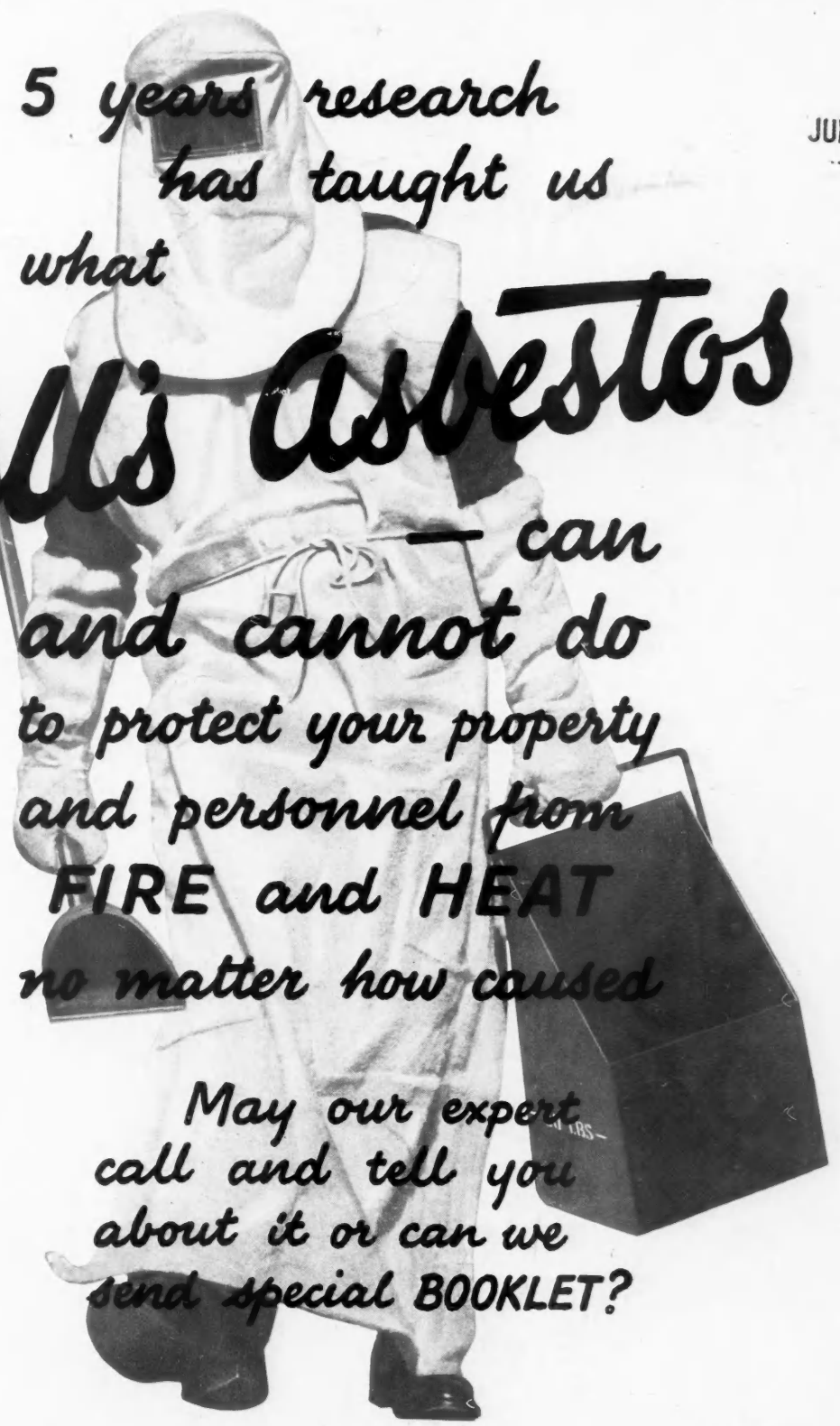
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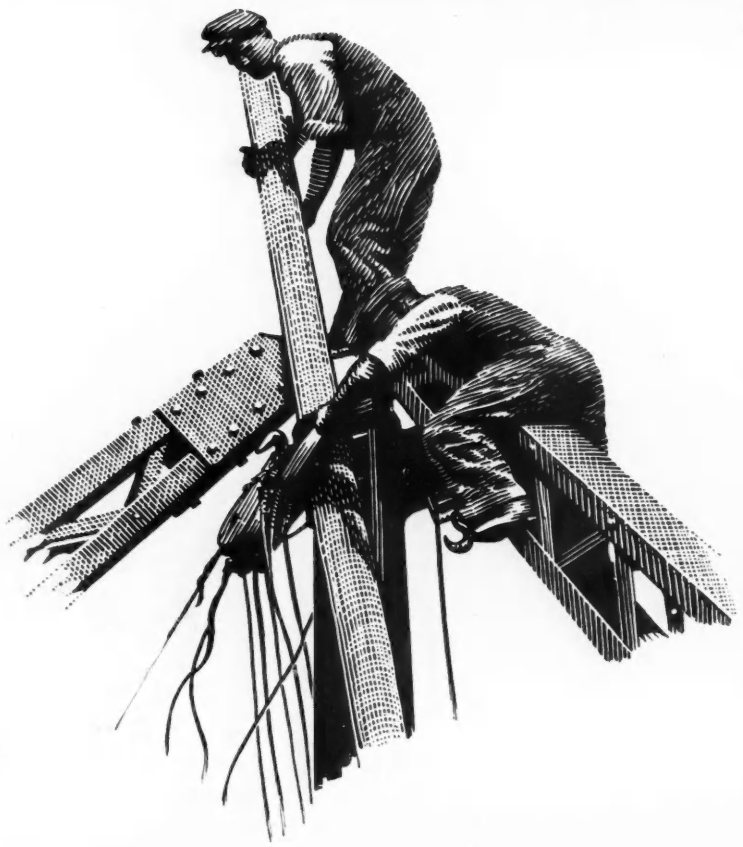

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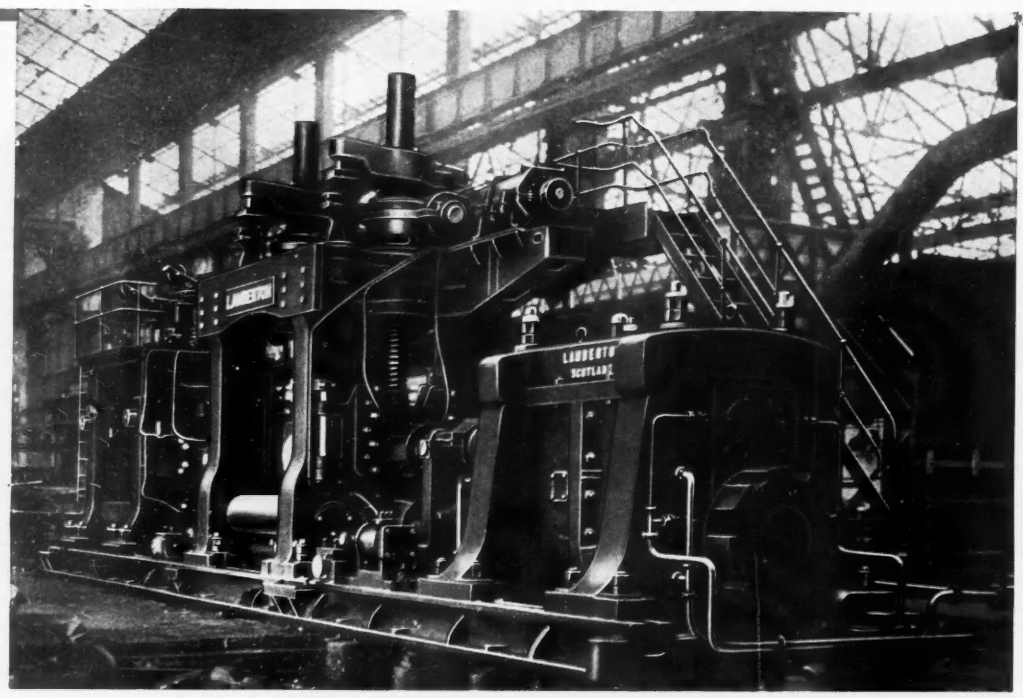

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National Census of Machine Tool Working Hours

IN order to help in speeding up the national output of arms the Production Council has asked the Ministry of Supply to take an immediate census of the hours during which machine tools in the engineering and allied industries are operated. The census applies to Great Britain and Northern Ireland. For this purpose the Ministry of Supply has circulated census forms, through the machinery of the Ministry of Labour, to all works of the following kinds :—Engineering, ironfounding, boiler-making, motor vehicle, aircraft, metal, instrument-making, and shipbuilding. The forms should have reached the works by Saturday last, and records of hours operated are to be kept for the week beginning at midnight on Saturday last, June 1st. The Minister of Supply is aware that the taking of records and the filling in of the forms, simple though they are, imposes an additional burden on managements at a difficult time. The work, however, is absolutely essential to the early success of the national arms drive, and the Minister appealed for the co-operation of all managements, confident that he might count upon a 100 per cent. response. Speaking at a conference held on Friday last, May 31st, Mr. Herbert Morrison, the Minister of Supply, said that there had been a splendid response to the Government's appeals for harder and longer work in the munitions industries. Already the rate of output showed the effect of the new spirit that animated the management staffs and the workpeople alike. Essential munitions were coming forward more swiftly, and the rate of growth in our arms production machine was accelerating. Although figures could not be given, Mr. Morrison went on to say that he had seen such figures and that the increase in the rate of output was very marked. There would be, he continued, problems and difficulties, and it was not possible to adapt our rate of production to the new phase of the war overnight. The questions to be settled would call for everything we possessed in the way of initiative, resource, and resolution.

Ministry of Aircraft Production Appointments

THE Minister of Aircraft Production, Lord Beaverbrook, announces that Mr. A. S. Quartermaine, B.Sc., M. Inst. C.E., Chief Engineer of the Great Western Railway, has been appointed Director-General of Aircraft Production Factories in the Ministry of Aircraft Production. He will co-ordinate and superintend the relative priority and progress of work in connection with the erection and equipment of factories for the construction of air frames, aero-engines and components. Mr. Arthur R. Cooper, M. Inst. C.E., M.I.E.E., who was appointed Director of Air Ministry Factories by Sir Kingsley Wood, has consented to continue to serve in that capacity. Mr. T. C. L. Westbrook has been appointed to take control of all aircraft purchases from Canada and the U.S.A. Sir Frank E. Smith, F.R.S., has been appointed Controller of Telecommunications Equipment.

The Ewing and Parsons Memorial Medals

AT a meeting of the Institution of Civil Engineers held on Tuesday, May 28th, the James Alfred Ewing Medal and the Sir Charles Parsons Memorial Medal were presented to the respective recipients for 1939. The James Alfred Ewing Medal was founded in 1936 in memory of the late Sir Alfred Ewing, Hon. M. Inst. C.E., and is awarded to a person, whether a member of the Institution or not, for specially meritorious contributions to the science of engineering in the field of research. The first award, for 1937, was made to Mr. Charles Samuel Franklin, and the second, for 1938, to Professor Arnold Hartley Gibson, D.Sc., M. Inst. C.E. The recipient for 1939 is Professor Geoffrey Ingram Taylor, Fellow and Yarrow Research Professor of the Royal Society and Fellow of Trinity College, Cambridge, who is distinguished for his development of various aspects of mathematical physics, many of which have found applications of great importance in the engineering field. His work on the problem of the turbulent fluid, with special relation to air movements and tides, has furthered knowledge of meteorology, and has been applied with particular success to problems of aeronautics, being of material assistance to the fruitful use of the wind tunnel. He gained a pilot's certificate at Brooklands in July, 1915. He is also a pioneer in the field of research into the conditions in solid bodies during strain, plastic deformation, fatigue, and creep. The practical character of his researches is exemplified by his work on the torsional stiffness of air screw blades, and he has forged new links between science and engineering to their mutual advantage. He was awarded the Royal Medal of the Royal Society in 1933. The Sir Charles Parsons Memorial was founded in 1936 in accordance with the report of an executive committee of the Royal Society. It comprises the erection of a memorial in Westminster Abbey, a Parsons Memorial Library, and an annual lecture on any of the subjects in which Sir Charles Parsons was interested, to be delivered by a distinguished man of any nationality, to whom a commemorative bronze medal is awarded. The lecturers are nominated in turn on the invitation of the Royal Society by the Institutions of Electrical, Mechanical, and Civil Engineers, the Institution of Naval Architects, the Institute of Marine Engineers, and the Physical Society, whilst the lecture in every fourth year is delivered on the North-East Coast, the nomination of the lecturer being made by the North-East Coast Institution of Engineers and Shipbuilders. The lecturer for 1939 was Henry Lewis Guy, D.Sc., F.R.S., M. Inst. C.E., who dealt with "Some Researches on Steam Turbine Nozzle Efficiency." Dr. Guy has been the chief engineer, mechanical department, of the Metropolitan-Vickers Company since 1919. He is a Whitworth Exhibitioner, Bayliss Prize Winner and Thomas Hawksley Medallist, and is a Vice-President of the Institution of Mechanical Engineers.

Reinforced Concrete and War-Time Building

IN view of the need for maximum economy in the use of steel in war-time construction, the potential savings in steel to be realised by reinforced concrete construction are reviewed in War-Time Building Bulletin No. 2, which has just been issued by the Building Research Station of the Department of Scientific and Industrial Research, and published by the Stationery Office. Using the single-storey flat-roofed designs given in Bulletin No. 1 as a basis, data are given showing that only a half or a third of the weight of steel may be necessary if reinforced concrete is used in place of structural steel. A diagram shows the relation between the weight of steel per 100 square feet and the spacing of the vertical supports for various types of construction. For reinforced concrete, spans of from 20 to 30ft. are found to be desirable. There is a shortage of material for shuttering, but considerable stocks are in existence, and some suggestions are made for utilising this supply to the best advantage. Unnecessary architectural features, such as recessed panels, plinths, &c., should be eliminated or reduced, and formwork should be stripped at the earliest moment consistent with safety. A table of suggested times is given, but the Bulletin stresses that with reinforced concrete construction it is essential that buildings should be erected only under expert supervision by firms specialising in this type of work. Shuttering could be saved, also, by the use of promising systems of precast construction, although the cost would be correspondingly higher. It is intended in future Bulletins to put forward a number of type designs which represent so far as possible the most economical and efficient use of reinforced concrete for factory construction.

Investigation of Atmospheric Pollution

REPRESENTATIVES of local authorities and other bodies co-operating in the investigation of atmospheric pollution met, by courtesy of the London County Council, in conference at the County Hall on May 28th. Among others, representatives of Cardiff, Dagenham, Glasgow, London County, Halifax, Manchester, Newcastle, Salford, Sheffield, Rotherham, Westminster, the British Commercial Gas Association, and Cadbury Brothers, were present. The Conference, in considering its annual report to the co-operating bodies, unanimously agreed that while contribution to the war effort was the first duty and desire of every organisation, the need for vigilant attention to the purity of the atmosphere had by no means decreased since the outbreak of the war. The wasteful burning of fuel and the detriment which pollution caused to the nation's health were stressed as two aspects of the problem which must not be forgotten, particularly in war time. The Conference therefore urged all local authorities to do whatever lay in their power to maintain the investigation. At the close of the meeting Professor W. H. Roberts, M.Sc., F.I.C., of Liverpool, was unanimously elected Chairman of the Conference, in succession to Alderman Adams, of Newcastle, who had held that office for three years in succession.

The Petroleum Board

IT is announced that the Petroleum Board, which was established on the outbreak of war in order to secure the maximum efficiency in the distribution of oil and petrol, has now been registered as a company limited by guarantee, without share capital. The registration does not mark any change in the operations of the Board, which is a voluntary organisation of distributors of petroleum products and benzole in the United Kingdom. The parties which have joined the scheme have pooled their resources, which have been placed under a unified control, with a view to enabling the best use to be made of the storage and distribution facilities and the man power. The relations between the Government and the Board are largely concerned with price fixing. The Chairman of the Board is Sir Andrew Agnew, managing director of the Shell Transport and Trading Company, Ltd., and the following are directors :—Mr. Rolland Beaumont, director of Trinidad Leaseholds, Ltd.; Mr. Gerald G. Bell, director of the Anglo-American Oil Company, Ltd.; Sir William Fraser, deputy chairman and director of the Anglo-Iranian Oil Company, Ltd.; Mr. Frederick Godber, director of the Shell Transport and Trading Company, Ltd.; Mr. Frank L. Halford, director of Shell-Mex and B.P., Ltd.; Mr. Albert Hittinger, managing director of the National Benzole Company, Ltd.; Mr. Alexander L. McColl, chairman of the Vacuum Oil Company, Ltd.; Mr. Alexander J. N. Singleton, director of the Texas Oil Company, Ltd.; Mr. Emil E. Soubry, vice-chairman and managing director of the Anglo-American Oil Company, Ltd.; and Mr. Simon J. Vos, oil manager.

The Tank Committee

SPEAKING in the House of Commons on Wednesday, May 29th, the Minister of Supply, Mr. Herbert Morrison, said that he had decided in consultation with the Secretary of War to appoint a Tank Board, to consider the whole subject of the construction and design of tanks. The Board, he said, would be asked to proceed with all expedition in dealing with this urgent and vital matter. Mr. Morrison announced that he had secured the services of Sir Alexander Roger as Chairman of the Board. Sir Alexander is Chairman of British Insulated Cables, and was a former Chairman of the Birmingham Small Arms Company, Ltd. Other members of the new Tank Board appointed by Mr. Morrison include Mr. A. A. M. Durrant, Chief Engineer of the Buses and Coaches Department of the London Passenger Transport Board; Mr. H. J. S. Moyses, managing director of the Birmingham Railway Carriage and Wagon Company, Ltd.; and Mr. D. W. Thompson, a member of the General Council of the Trades Union Congress. Mr. Morrison announced that further members would be appointed by the War Office and the Ministry of Supply, and that the names of these members would be announced at a later date when the appointments were made.

British Naval Losses off Dunkirk

IN the course of a speech made in the House of Commons on Tuesday, June 4th, Mr. Winston Churchill, the Prime Minister, stated that the Royal Navy, using nearly 1000 ships of all kinds, had been able to evacuate over 335,000 men, French and British, from Dunkirk. In an official statement made by the Admiralty on Monday evening, reference was made to a total of 222 British naval vessels and 665 other British craft and boats which had taken part in the operation. The naval losses include the three destroyers, H.M.S. "Grafton," H.M.S. "Grenade," and H.M.S. "Wakeful," the loss of which was announced on May 30th. Other losses since sustained by enemy action off Dunkirk include three destroyers, H.M.S. "Basilisk," H.M.S. "Keith," and H.M.S. "Havant." Of the more than 170 minor war vessels of H.M. Fleet which were engaged in the operation the following twenty-three have been lost :—One Fleet minesweeper, H.M.S. "Skipjack"; one gunboat, H.M.S. "Mosquito"; one Fleet Air Arm tender, H.M.S. "Grive"; four paddle minesweepers, "Brighton Belle," "Gracie Fields," "Waverley," and "Brighton Queen"; one minesweeper, "Crested Eagle"; eight trawlers, "Polly Johnson," "Thomas Bartlett," "Thuringa," "Calvi," "Stella Dorado," "Argyllshire," "Blackburn Rovers," and "Westella"; three drifters, "Girl Pamela," "Paxton," and "Boy Roy"; two armed boarding vessels, "King Orry" and "Mona's Queen"; one minelaying vessel, "Comfort"; and one tug, "St. Fagan." It is further announced that the port of Zeebrugge has been blocked by the sinking of concrete-filled block ships, while the sea gates of the canal and lock working mechanism have been destroyed, and the lock gates blocked. The other ports now in enemy hands have been rendered useless and the fuel stocks have been destroyed. The Navy made its first attempt on May 25th to seal Zeebrugge, but weather conditions were too difficult for the block ships to be taken right up the canal. They were, therefore, sunk in the harbour entrance. A second attempt 24 hours later with two more block ships resulted in the canal entrance being effectively blocked. No loss of life occurred.

Water Supply of Rangoon, Burma

No. II

(*Continued from page 489, May 31st*)

DIVERSION TUNNEL AND VALVE TOWER

AS has already been mentioned, an arch dam 40ft. in height was constructed to divert the waters of the Gyobyu from the area where the main dam was to be constructed. The water was diverted through a tunnel driven through the side of the gorge on the left bank of the river. A section through the tunnel is reproduced in Fig. 10. It has a horse-shoe shape equivalent in cross-sectional area to a circle 13ft. in diameter and is 760ft. long. The valve tower has been built vertically above it, near its upper end, and when the dam has been completed a concrete plug will seal the mouth of the tunnel. In order to facilitate this work, the 14ft. length of tunnel between the valve shaft and the mouth was built with 13ft. diameter cast iron rings backed up with concrete. This work was carried out in the open, and a temporary bell-mouth was placed at the entrance. The bulkhead which will seal off the tunnel mouth is to be formed of cast iron segments backed up by concrete filling. In order to deal with the flow of the river during the period when the bulkhead is being built, a scour pipe has been laid below the invert of the tunnel.

The design of the valve tower which surmounts the tunnel is shown in Fig. 11. This tower is also to be seen in the half-tone engravings, Figs. 3 and 8 (*ante*) which also show the reinforced concrete arch bridge which connects it with the shore. The tower has an internal diameter of 20ft. and contains a 56in. cast iron standpipe resting on a duckfoot bend connected to the 56in. steel supply main that passes down the tunnel. Three intakes are arranged on the standpipe at levels respectively 14ft., 35ft., and 77ft., below overflow level of the reservoir. The valves of these intakes are operated from platforms reached by a spiral staircase from the valve house.

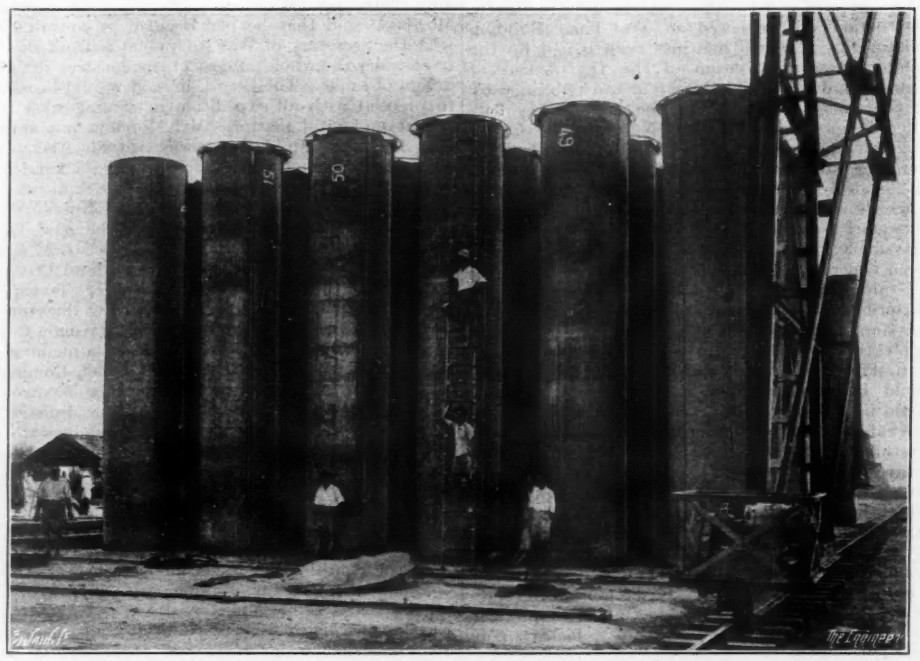


FIG. 9—PIPES IN CURING YARD

THE PIPE LINE

It has already been mentioned that water from the reservoir in the Pegu Yomas hills is conveyed to the Kokine service reservoir at Rangoon in a pipe line. The pipe line, which has a length of 43½ miles, is made up of steel sections 25ft. long, and has an external diameter of 58in., and a thickness of $\frac{7}{16}$in. The route followed passes over many miles of paddy fields at an elevation but little above tidal level. As it was considered impracticable to lay pipes of so large a diameter below ground level apprehension was felt lest the temperature of the water would rise considerably, since the pipes are exposed to the rays of the sun. Information was, however, received that in the Tansa main for the supply of Bombay, which is also laid above ground, no trouble had been experienced owing to heating of the water.

The contract for the supply of the pipes was secured by Braithwaite, Burn, and Jessop. That company erected works for the fabrication of the pipes about 4 miles from Rangoon at a situation at which convenient access was available by road, rail and water. Steel plates $\frac{7}{16}$in. thick supplied by the Tata Iron and Steel Company were shipped to Rangoon and formed into pipes by bending groups of three plates to shape and welding together electrically. In order to protect the pipes from internal corrosion; to add rigidity so that they did not deflect appreciably under their own weight (a matter of importance when couplings are used); and to reduce the rise in temperature of the water, the pipes were lined internally with fine Portland cement concrete 1in. thick by a spinning process at the works. An accompanying engraving (Fig. 9) shows a number of pipes in the curing yard at the works. Reliance is placed on three coats of paint to provide protection against external corrosion. The individual pipes are connected together by "Dresser" couplings manufactured in America and similar in design to the "Johnson" coupling which is more familiar in this country.

For the purpose of laying the pipe line, a 2ft. 6in. gauge railway was constructed, running alongside the line of the pipe. The formation was sufficiently wide, as shown in Fig. 12, to provide not only for the railway and the pipe line, but also for a travelling gantry by the use of which each pipe was lifted from the special railway wagons into place on concrete pedestals. One such pedestal is provided at the centre of each pipe on the straight runs and two on curves. The pipes are grouted to saddles which surmount the pedestals. With the object of avoiding the necessity to use thrust-blocks and also to facilitate railway transport flat curves were adopted. The usual radii were 2500ft. in plan and 1250 ft. for vertical curves. Where they were to be laid on curves the ends of the pipes were bevelled at the factory so that adjacent pipes butted together properly and undue strain was not therefore exerted on the couplings.

The construction of the pipe line involved the building of no less than 80 bridges to carry it over a number of streams and other obstacles. Sluice valves are placed at intervals of 5 miles, air valves are situated at all summits and washout valves at all depressions. Where the pipe line passes the existing Yegu pumping station, not far from Rangoon, it is provided with a valve and branches. To these branches the suction and delivery pipes of booster pumps are to be connected if it is found necessary to deliver more than 20 million gallons per day into the service reservoir. The use of boosters will make it possible to increase the delivery to 30 million gallons per day. The water is discharged into the existing Kokine service reservoir after passing through two float-operated balanced valves, arranged gradually to shut off the supply of water as the level in the reservoir rises to within 3in. of the top water level, 150ft. above datum.

Gantries for the laying of the pipe-line were supplied by the Braithwaite, Burn, and Jessop Company, which was also responsible for laying

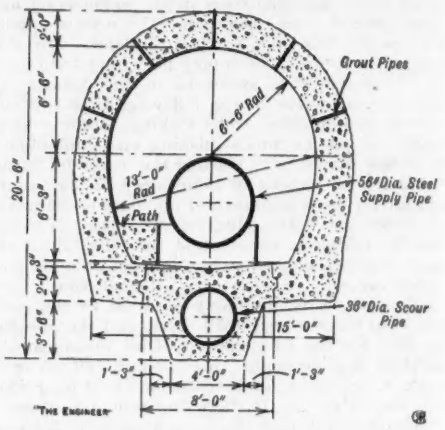


FIG. 10—SECTION THROUGH TUNNEL

and testing the pipeline. The construction and maintenance of the railway and haulage along it were, however, the Rangoon Corporation's responsibility. Rolling stock for the railway was supplied by Robert Hudson, Ltd., valves in the pipe line were supplied by Glenfield and Kennedy, Ltd., and the Stanton Ironworks Co., Ltd., provided a number of cast iron "specials."

COAGULATING BASIN

The water supplied to Rangoon from Hlawga lake is not filtered before delivery into the Kokine reservoir. About $\frac{5}{6}$ths of the rainfall contributing

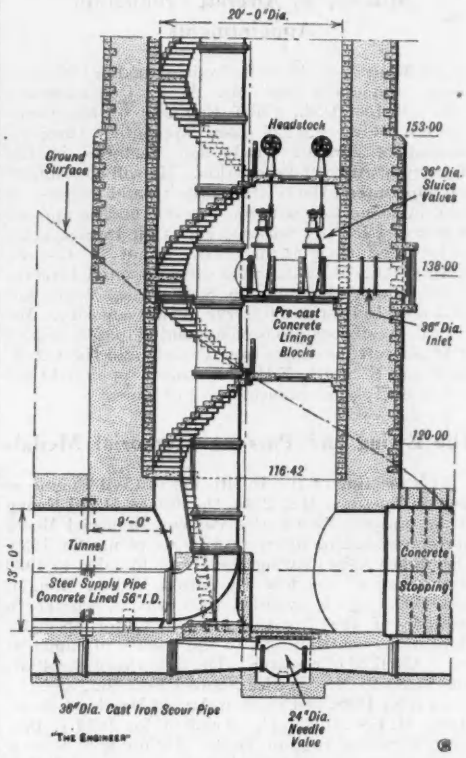


FIG. 11—SECTION THROUGH LOWER PART OF VALVE TOWER

to the supply of the Gyobyu reservoir runs off steep mountain sides and carries in flood time a considerable quantity of matter in suspension. It was feared that the water from this source might compare unfavourably in appearance with that supplied from Hlawga lake and it was therefore decided to reduce the turbidity by the addition of coagulants. Although the turbidity would be considerably reduced by coagulation, the fine "floc" would not all settle to the bottom of the sedimentation tanks and some of it would be carried into the supply main. Experiments were therefore carried out to ascertain the best way of removing the fine "floc." They led to the

adoption of rotary self-cleansing screens of the "Peebles" type supplied by Glenfield and Kennedy, Ltd. These screens are made of Monel metal and have 80 apertures to the linear inch.

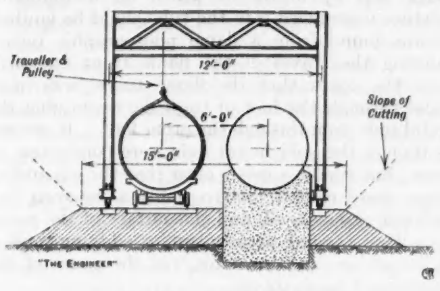


FIG. 5—PIPE LAYING GANTRY

The submerged screen area and the speed of rotation are so arranged that there is not more than 2in. difference in water level between the two sides of the screens when water is passing through at the rate of 30 million gallons per day. The water is sterilised by the Chloramine process before entering supply.

The coagulating basin is situated about 1500 yards below the valve shaft at the Gyobyu dam. Entering water passes through ¼in. mesh strainers to a "header" pipe provided with twenty 12in. ball valves. These valves regulate the rate of discharge into the basin so as to maintain a constant water level with varying rates of flow in the 56in. outlet main and varying levels in the main reservoir.

We are indebted to the consulting engineers for the whole Pegu Yomas scheme, Messrs. Binnie, Deacon, and Gourley, of Westminster, for permission to reproduce the accompanying drawings and photographs and for providing the material upon which this article is based. Mr. A. E. Mann, M. Inst. C.E., the Chief Engineer of the Rangoon Municipality, is associated with the consulting engineers in the construction of the works. The chief resident engineer for the scheme is Mr. E. C. Steer, M. Inst. C.E., and the resident engineers for the pipe line and headworks respectively are Mr. F. R. Melville, M. Inst. C.E., and Mr. R. Le G. Hetherington, Assoc. M. Inst. C.E.

The Process of Combustion in Spark Ignition Engines

By Professor W. T. DAVID

THE large number of photographs which have been taken of flame travel in closed vessel explosions make it possible to build up an accurate picture of the combustion process in spark ignition engines. They show that some of the older theories are untenable. For example, it used to be thought that the influence of turbulence upon combustion was due to the breaking up of the nucleus flame initiated by the spark into small parts which were carried to various parts of the combustion chamber, thus virtually setting up large numbers of ignition centres. But flame photographs show that flame propagation in turbulent mixtures takes place

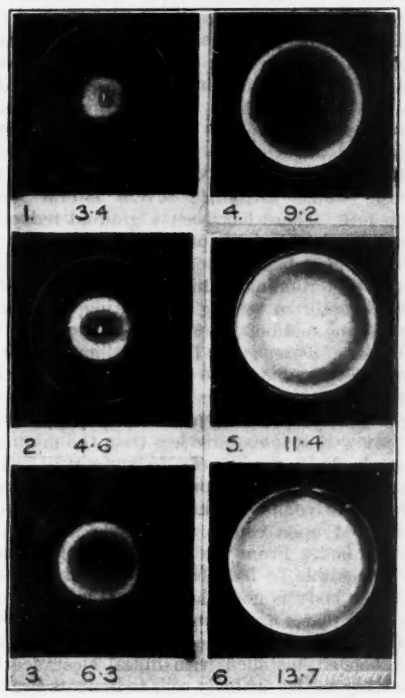


FIG. 1

much as in stagnant mixtures—though, of course, the propagation is very much more rapid in turbulent mixtures. Again, it was once thought that the delay period in spark ignition engines was due to ignition lag, but flame photographs clearly show that a considerable volume of combustion takes place during this period, and that ignition lag only accounts for a minute fraction of it. The delay period combustion is, however, uninfluenced by turbulence. An attempt is made in this article to picture the combustion process, and to offer some explanation.

Let us take first the simplest possible case, namely, that of flame propagation through a stagnant inflammable gaseous mixture contained in a closed spherical vessel after central ignition. A series of instantaneous snapshots taken by Ellis[1] is shown in Fig. 1. The figures below each photograph show the times after ignition in milli-seconds at which the photograph was taken. The spherical vessel used by him was transparent and initially contained a gaseous mixture consisting of 32·35 per cent. CO and air. Attention is called to the increasing brilliance of the flame front with distance of flame travel from the igniting spark. This is of interest in connection with the views put forward later in this article. A photographic record of the flame front travel outwards from the spark taken upon a film moving at a constant speed is shown in Fig. 2. For the purpose of this record, which was also taken by Ellis, the spherical vessel was painted black except for a narrow equatorial slit through which movement of the flame front was photographed. In this figure is also shown a continuous record of the rise of pressure of the exploding gases within the vessel. From the flame record it will be seen that the rate of flame travel is not uniform. Immediately after the passage of the spark, a minute ignition lag period is noticeable. Thereafter the flame spreads outwards, but, as may be seen from the pressure record, there is no sensible rise of pressure in the vessel until the flame has travelled over a distance equal to at least ⅓th of the radius of the sphere. This "pre-pressure" period cannot be influenced by turbulence, as may be clearly seen from the pressure records in Fig. 3, which were made in an explosion vessel in which a fan was fitted.[2] It will be seen that however great the turbulence, which was dependent upon fan speed, the pre-pressure period was uninfluenced, though the later stages of combustion were markedly influenced, and to an extent dependent upon the degree of turbulence. The "delay period" in spark ignition engines is equivalent to the pre-pressure period in closed vessel explosions, and similar information in regard to the delay period in petrol engines may be obtained from the indicator records made by Ricardo [3] replotted to a time base in Fig. 4 and the record of flame travel across the combustion space taken by Withrow and Boyd[4] shown in Fig. 5. It will be seen from Fig. 5 that a considerable volume of combustion takes place during the delay period, that is before the pressure due to combustion begins to rise, but it will be clear from Fig. 4 that the duration (in time) of this period is the same whether the engine runs at 1000 r.p.m. or 2000 r.p.m., in spite of the fact that the turbulence created during the entry of the charge varies as the speed. The rate at which the subsequent stages of combustion take place increases as the speed of the engine increases, that is as the turbulence increases, as may be inferred from the rate of rise of pressure at the two speeds shown in Fig. 4.

These experimentally ascertained facts present a difficult problem. Why should the subsequent stages of combustion be so markedly influenced by turbulence, whereas the initial stages of combustion are quite uninfluenced by it? The answer would appear to be that the mode of flame propagation during the initial combustion is very different from that during the subsequent combustion.

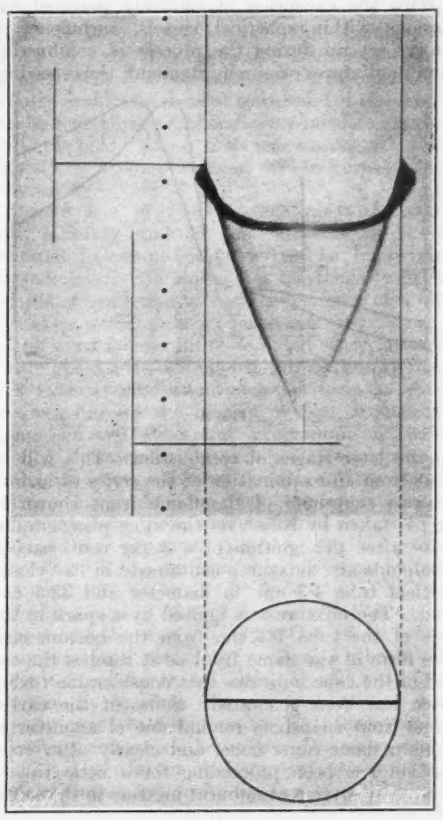


FIG. 2

Flame may be propagated by the diffusion of activated atoms and molecules from the flame front into the adjacent unburnt mixture, that is, by chain reaction mechanism, or thermally as a result of the conduction and radiation of heat from the flame front into the unburnt gas. It seems certain that the mode of flame propagation during the initial burning is by diffusion of activated atoms and molecules, and it is easy to see that turbulence should have no influence upon it. It also seems certain that during the subsequent stages flame is propagated mainly by the thermal

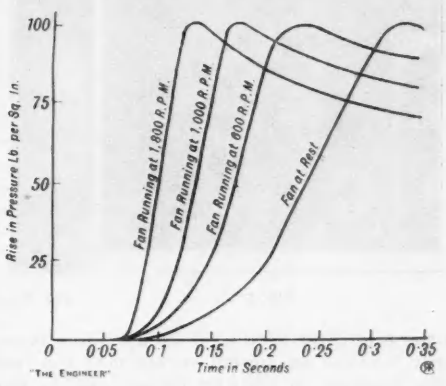


FIG. 3

mode, for, as is well known, the instantaneous temperature as well as the instantaneous pressure in the flame front increases greatly with distance of flame travel. But it is not so easy to see why turbulence should have its marked influence during this mode. The instantaneous photographs taken by Ellis [5] and shown in Fig. 6 are of assistance in this connection. They were taken during the explosion of a 20 per cent. CO-air mixture contained in a glass spherical vessel in which a fan was mounted. The mixture was centrally ignited 15 seconds after the fan was set to run, and the first photograph was taken 28·8 milli-seconds after ignition, and the second one 20 milli-seconds later.

[1] Journal Chemical Society, February, 1927, page 310.

[2] THE ENGINEER, December 31st, 1937, page 734.

[3] Proceedings, Inst. Aut. Engrs., March, 1930, page 647.

[4] Industrial and Engineering Chemistry, Vol. 23, page, 539, May, 1931.

[5] *Fuel*, Vol. VII, No. 12, page 532.

It will be seen that the flame front surface is not smooth as in the photographs shown in Fig. 1 for a stagnant mixture, but shows marked irregularities. On account of these the area of the flame front surface is greatly increased. The amount of adjacent unburnt gas subject to heating from the high temperature flame front is thus greatly increased and consequently there is a speeding up of combustion. It will be clear that the more violent the turbulence the greater will be the flame front irregularities, and therefore the greater the speeding up of combustion.

With the exception of centrally initiated explosions within spherical vessels, turbulence is always set up during the process of combustion even in mixtures originally stagnant, thus speeding

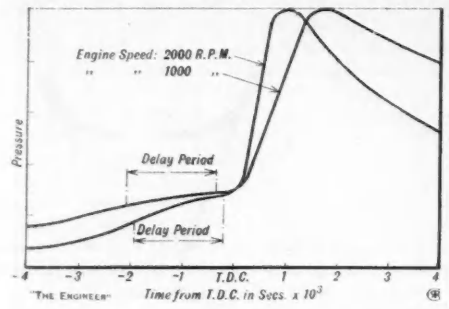


FIG. 4

up the later stages of combustion. This will be clear from an examination of the series of instantaneous snapshots of the flame front shown in Fig. 7, taken by Ellis[6] on the same photographic plate after the ignition of a 3 per cent. carbon disulphide-air mixture contained in a closed vertical tube 4·3 cm. in diameter and 32·5 cm. long. The mixture was ignited by a spark in the axis of the tube 7·3 cm. from the bottom end. The form of the flame front as it reaches the top end of the tube indicates that considerable turbulence has been generated. Some of the earlier flame front snapshots remind one of an inverted Bunsen flame inner cone, and clearly after combustion has been proceeding for a little time a downward stream of unburnt mixture in the centre

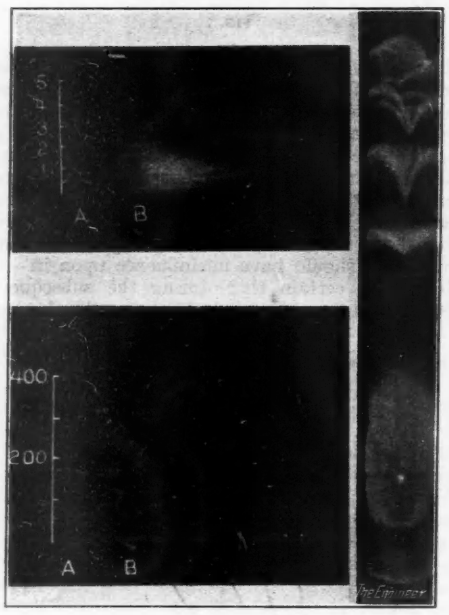


FIG. 5 FIG. 7

of the tube must have been set up. This necessarily involves an upward stream near the tube walls resulting in eddying motion due to skin friction, and the general and eddying motion gives rise to a turbulence in the unburnt mixture sufficient to produce the much distorted flame front near the top of the tube. The 3 per cent. carbon disulphide is a relatively slow-burning one, and it can be well imagined that with rapidly burning mixtures the turbulence generated would be very great. Indeed it is so great in rapidly burning mixtures, such as strong hydrogen mixtures, that it completely overwhelms turbulence generated by a rapidly revolving fan placed in an explosion vessel. This is inferred from the effect upon the rate of cooling of the hot gas of the combustion generated turbulence persisting after explosion as described in a previous article.[7]

[6] *Fuel*, Vol. VII, No. 10, page 452

[7] THE ENGINEER, December 31st, 1937, page 733.

Exceptionally, as has been stated, turbulence is not generated during the process of combustion in centrally ignited spherical vessel explosions, as may be seen from the flame front snapshots in Fig. 1. But there seems little doubt that even in such explosions a turbulence, the violence of which increases with the rapidity of explosion, is generated

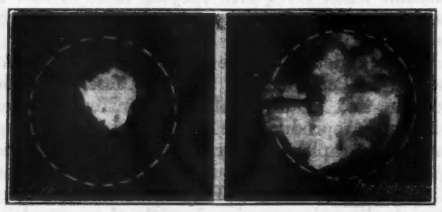


FIG. 6

as the flame contacts with the surface at the end of explosion—due, possibly, to slight irregularities in the interior surface of the spherical vessel.

Combustion-generated turbulence provides an explanation of an experiment of considerable interest made some years ago. A glass tube of 2in. diameter and 20in. long was fitted with closely fitting end covers, through the centre of one of which two pairs of stout metal rods, 10in. long, projected so that they reached half way across the tube. One pair was arranged to form a central spark gap by means of which an inflammable mixture introduced into the tube could be ignited. It was found from a flame photographic record showing the travel of the flame front outwards from the spark that the flame travel was more rapid through the half of the tube containing the metal rods than through the other half. It seemed as though the cold metal rods were conductors of flame, but it now appears clear that the expanding flame gases caused relative motion between the unburnt gases ahead, and the surface of the metal rods, thus causing a turbulent or eddying motion to be set up, and that this was the cause of the more rapid flame travel.

In some other experiments it was found that inflammable mixtures introduced into a closed vessel exploded more rapidly when some cold stout wire coils were inserted in the vessel than when the wire coils were removed. Again the explanation would appear to be in terms of turbulence set up during the process of combustion.

I should like to thank Dr. O. C. de C. Ellis and Dr. T. A. Boyd for permission to reproduce their instructive flame photographs.

Mastering Momentum in Transport*

By L. K. SILLCOX†

No. IV

(*Continued from page 501, May 31st*)

Conventional Equipment.—Two coupled passenger cars, fitted with spring buffers, offer maximum resistance to the horizontal displacement of one car end. Lateral oscillation of heavy, conventional cars, closely coupled, has not been objectionable, particularly since they invariably have been carried upon six-wheel trucks of remarkable inherent lateral stability. Even the oscillating tendencies of the coned wheel treads with which the trucks are fitted are unable to develop a synchronous lateral movement.

Rear Truck Tendencies.—Lateral oscillation of the rear end of the last car is common when the car is carried upon a four-wheel truck. The period of oscillation is relatively brief at low to moderate speeds and the amplitude is but slightly affected by the inertia of the mass carried. Thus, the direction of the wheels is able to reverse itself freely, without depending upon flange contact. Under these conditions, the lateral motion is not noticeable within the car. Now speed up the train, the oscillating tendencies, as governed by tread contours, remaining active as before. Pronounced inertia forces are built up in a lateral direction, increasing the amplitude of truck swing before reversal of direction occurs. The car body rolls, pivoting at the centre plate and resisted by the bolster springs. Car body roll and the lateral oscillation of the truck synchronise. The lateral swing grows more violent and sweeps across the rails with greater amplitude. Finally, truck direction is not reversed by the operating of treads upon different diameters and the flange throat radius is passed. A severe blow is struck at the flange and the resonance is broken, but not without pronounced disturbance within the car body.

A Case for the Cylindrical Tread.—The introduction of high speeds, light weight, and the return of the 4-wheel truck in passenger service occurred simultaneously. Few 6-wheel trucks are operated at the rear of modern fast trains where observation cars and sleepers—cars of the heaviest type—had been hauled before. Rear end whip was observed and discussed. Various expedients were attempted to stabilise the car at this location and, finally, cylindrically ground wheels were applied, removing the most prominent cause for car end oscillation. Four-wheel truck cars with conventional ends and buffers, when coupled within the train, do not present the same difficulties. The rigid buffer connection damps out resonant tendencies by introducing opposing forces from the adjoining car. However, with tight lock couplers and the elimination of the buffer, four-wheel trucks at the ends of intermediate cars within the train are able to follow their own serpentine courses down the track. With less freedom than the last truck of the train, the high frequency, large amplitude oscillations do not develop critically but the tendency can be discerned. They are clearly visible in the handling of freight trains at high speeds. Cylindrical treads should and doubtless will be adopted as standard for all such installations. The virtue of the tapered tread is fancied rather than real and, as long as it is installed, whether the taper be intended or developed through service wear, the tendency to oscillate will be present and, though its effect is reduced in magnitude by close tolerances in truck construction and exact parallel disposition of axles, it cannot be eliminated. The centreing tendency secured by tread taper is a function of supported weight and angle of the taper. An angle, sufficiently steep to be of distinct benefit for the purpose, would introduce severe lateral forces at the rail. There has been a gradual reduction in the amount of taper provided until, at 1 : 40, the centreing effect is negligible. However, the difference in running radii at axle ends is still a material factor in setting up hunting, sometimes called nosing, action.

Car Body Suspension.—The swivelling truck is an American contribution to the railway equipment designs of the world. It is never omitted unless the weight of any specific type of equipment is sufficiently low that it requires less than the minimum eight wheels in two trucks to support it. This does not frequently occur in American practice. With two swivelling trucks provided, the car body is balanced upon centre plates, one adjacent to each car end. From the standpoint of stability it is impossible to balance a body at two points and a car body is not inherently stable, although the centre plates are given substantial area. Side bearings are widely spaced upon each car and truck bolster, installed with initial clearance but contacting as the car body rolls to limit its swaying tendencies. The suspension of steam locomotives and others of comparable wheel arrangement is so disposed as to provide three-point support, the only form which provides ideal stability and equalisation of load under all conditions of uneven track. Refinements in side bearings, reducing or eliminating initial clearance and providing resilience within the bearings themselves, have been successfully introduced, modifying the evils of a design which is structurally undesirable but not readily corrected without interfering with the free-swivelling action of the trucks. Widely spaced car body supports at one end, with long suspension links or guided rollers, allowing the truck to turn about its vertical centre without introducing too high restraint, would be desirable, the opposite end resting upon a conventional centre plate.

* A Discussion of Modern Transport Trends and their Influence upon the Equipment of American Railways, Massachusetts Institute of Technology, 1940.

† First Vice-President, The New York Air Brake Company.

This would provide three-point suspension, but would interfere with complete interchangeability of trucks, and space for the accommodation of links of the desired length would be difficult to arrange. A similar type of construction, but one which employed links at the bolster ends of both trucks, providing four-point suspension, was in use forty years ago on one type of freight car truck. Freedom of car body movement was allowed longitudinally and laterally, and, while the cars were well known for their excellent riding qualities, maintenance difficulties and the potential hazard of a system which allowed a momentary release of load on guiding wheels prevented extended application or its modification to a similar but less complex form. On the whole, the conventional system of car body suspension has worked out well and recent improvements have been witnessed which direct attention from the fundamental objections to centre plate bearing.

Novelties in Truck Design.—There is a growing sentiment which favours the abandonment of many of the commonly accepted principles around which the conventional passenger car truck has been developed. Long truck wheel bases are no longer universally viewed as essential to lateral stability. The wisdom of superimposing spring groups of varying natural frequency of oscillation, serially, one upon another, complicating the design and adding weight, is being questioned. Elimination of springs altogether and the substitution of rods in torsion has been suggested, but so daring a departure is still a project for further investigation. Elliptic spring groups, with the friction between spring leaves damping oscillation, are losing favour—first in automotive practice and more recently in railway car construction. Truck frame pedestals, furnishing vertical guides for journal box movement, are being supplanted because objectionable clearances develop rapidly with wear. Later designs have employed radius rods for maintenance of alignment of axles, longitudinally or both laterally and longitudinally. Helical springs with external damping mechanism have replaced elliptic patterns throughout some truck designs.

Simplification in Truck Design.—Changes of the type described are quite unique in railway practice. Still more revolutionary innovations are in prospect which recognise the necessity for reduction in truck weight if control is to be reasonably exercised over car body motions. As car body weights have constantly diminished, the weight of the four-wheel trucks which support them has increased, improvements being incorporated more completely to insulate the passenger from shocks and noise arising from the imperfect roadbed and from the reactions of truck parts themselves. The single bolster drop equaliser truck of familiar construction, with the truck frame carried on unsprung equalisers through helical springs, and the bolster suspended from the truck frame on elliptic springs, has given way to the double, triple, and even quadruple bolster patterns, each one adding another series spring group and more weight. Not only is the additional weight costly to acquire and transport, but a heavy truck structure, spring suspended between journal boxes and car body, introduces material interference with normal spring functions and, consequently, with riding qualities as observed within the car body. Strange new patterns are appearing, some having reached the service stage abroad, where the light weight of small railway cars affords a more suitable experimental application than do the cars on our railways which, although demonstrating important weight economies as compared with the cars displaced in long-distance, high-speed service, yet require very sturdy, well co-ordinated trucks to bear their weight.

Knee-Action Trucks.—A most unusual truck construction is that adopted by the Bernese Alps Railway Company. It is the centre truck, used at the articulation junction of two lightweight car bodies of a twin-car motor train. The truck is fitted with helical springs (in compression on bell-crank levers) only, provides full "knee-action" with the independent suspension of each of the four wheels, dispenses with axles between wheels, and carries no centre plate. Of skeleton construction offering extreme light weight, the truck is reported as producing exceptional riding qualities. Car body weight is carried upon rollers which permit the truck to swivel while maintaining bearing at widely spaced supports.

New U.S. Truck Designs.—New forms of experimental passenger car trucks providing weight economies and showing promise of practical application have been developed by two of our own large railway systems. One retains the side equalisers of modified conventional construction. Coil springs in parallel, tilted inwardly, are carried by these equalisers and support the bolster without intervening linkage. Torque rod stabilisers prevent excessive body roll while hydraulic snubbers damp out free oscillation of the coil spring groups. Lateral motion of the car body with respect to the trucks, accomplished by bolster suspension on swing links in the conventional construction, is compensated by allowing greater freedom in lateral roll, cushioned upon the single spring group.

Experimental Milwaukee Truck.—A second unique construction is still undergoing development tests by the Chicago, Milwaukee, St. Paul and Pacific Railway Company's engineering department. Rubber is generously employed as a spring medium and vibration insulator. A single concentric group of coil springs, widely spaced, at each truck, carries the car body. Of skeleton frame construction, having a wheel base of but 72in., and employing inboard bearings, this truck, if proven successful with respect to riding qualities, stability, utter reliability, and freedom from high maintenance expense, may very well revolutionise American railway equipment practice in passenger car truck construction. While less radical in design than the Swiss railway truck described, the Milwaukee truck has been designed with full recognition of the demands imposed by the long, high-speed runs of American railways. If adequate for this service, its simplicity and lightness will prove attractive to railways.

Hill Pendulum Car.—An unusual type of passenger car and truck has been developed in this country, meriting attention in view of the interest which it is attracting, two large western railways having placed orders for demonstration units. This is the Hill pendulum car. In the Hill car, one articulated twin unit of which has undergone road trial, the body is suspended from spring mounted pedestals carried by each truck. These rise well into the car body and are held within enclosures constructed in the passenger space. Since the centre of gravity of the car body is located well below the point of support on the pedestals, action of the car bodies on curves at speeds greater than that for which super-elevation is ideally suited is the reverse of that experienced with cars of conventional design since the body of the Hill pendulum car swings outwardly at the bottom in such case, imparting a feeling of security to the passenger and relieving him of lateral forces acting on his body. There are many details of construction which must be met in unusual manner in adapting this unique design to the requirements of railway service where the association of a number of cars is required.

Scope.—Obviously, we are entering a period of rapid change in truck construction. The availability of new materials of construction and railway determination to operate their trains faster, produced new train types five years ago. The first innovations were confined to car bodies and power units, the change being too rapidly effected to allow studied alterations in details. These are following and the car truck seems to hold the spotlight at the moment. Of the probability of important technical progress there can be no doubt. All the railways of the country will benefit by the pioneering that is now in process. Equipment design cannot be discussed with any sense of finality when the ideal suitability of all the railway inventory, including motive power and rolling stock, is being questioned, and enterprising designers are examining details with prophetic vision of future needs.

Opportunity.—The entire railway and railway equipment field invites the effort of competent young men. The industry is a century old and is weighted down with tradition and inviolate precedent. There is a disposition critically to examine railway practices in every direction. Perhaps it is true, as is often alleged, that railways were satisfied that they alone held the answer to the nation's transport problem and that they were serving well. When determined competition arose in a form which, abandoning the established principles of railway economics, still successfully sought public acceptance of alternate methods of travel and transportation of freight, the railways were unprepared to acknowledge that the new methods were sound and enduring. Yet they have proven to be so. Railways have been compelled to accept the broader view of the benefit to themselves and to the public which they serve. Change has only begun. Daring new practices are still the toys of a few administrations. As railways generally fall into the swing of change improvements will take permanent form and new fields will be explored. It requires fresh outlook and a mind which is unburdened with fear of daring departure to achieve the inevitable. There are opportunities such as have not been present since the days of railway pioneering.

Metamorphosis.—The railway train is not an unlovely thing of soot and grease—a dream shattering monster which plunges through the night, bearing down upon the unwary, supreme upon its exclusive right-of-way, with utter disregard for the tranquillity of persons along its course. Within or without the cars of modern trains relative quiet reigns. The characteristic pound of rods, driving boxes, and crossheads is passing. Black smoke is a signal for discipline. It is flatly prohibited in most towns and cities—and it can be controlled. Car bodies are insulated against heat or cold, noise, and grime. In all these directions accomplishment is incomplete but progressing.

Proper Use of Theory.—The forward step is still faltering and in some directions largely untested. Genuine progress can be made only by judiciously combining the teachings from the records of yesterday with the experience of to-day to make a working theory for to-morrow. Theory, as the word is used in its accepted sense, means a working hypothesis founded on all known facts and experiences, which may be used to guide progress beyond the margin of past accomplishments. Every successful programme is based upon a constant use of theory in its proper and utilitarian sense. Theory is not antagonistic to practice but is founded upon the application of active minds to the interpretation of experience as a guide to progress. Custom should prevail only when it has undisputable reason to support and justify it.

Social Aspect of Modern Transport.—Science has compressed the world to a fraction of its former dimensions and placed the well-oiled wheels of a modern age beneath us. We are still seeking to improve its bearings and are not satisfied with the lubricant which we are using. If there were no question, there would be no progress, so we can ill afford to be content with present achievements. Modern transport truly applies a multiplying factor to the potentialities of useful life in the busy and creative man. Each passing generation must enlarge its scope and effectiveness.

Challenge to the Young Engineer.—It has required many centuries for the world to discover that the great forces of nature are neither sacred nor profane—neither kind nor cruel—that they neither love nor hate—and that they are as permanent as the stars. They are given us for good or evil as we will—pliable in themselves. Out of all this broadening of the horizon of human activities has come the need for the technically educated man. Our industrial system needs men who can design, plan, and execute. Our success in new enterprises and progress in the old is found only in the education which is engineered into our products and into our methods of manufacture and distribution. Our natural resources are to be conserved. We are to be not only guardians, but thrifty administrators as well. There is plenty for each young technical graduate to accomplish as he steps from the lecture hall and laboratory to assume the responsibilities of an educated, well-trained citizen, confronting a new era which expects more from him, both in progress and rate of progress, than the past demanded from his predecessor. Before him lies a life dedicated to the first task of the engineer—that of "Mastering Momentum"—nor does this relieve him of his responsibility for the creation of momentum in good measure.

THE PRICE OF TIMBER.—A new order made by the Minister of Supply provides that prices for home-grown timber may be negotiated between buyers and sellers when prices are not already fixed by the Control Orders, and also in cases where prices are already fixed but in which the timber is of exceptionally large dimensions. In all such cases delivery of the timber may not be made until the Timber Controller has approved the negotiated price.

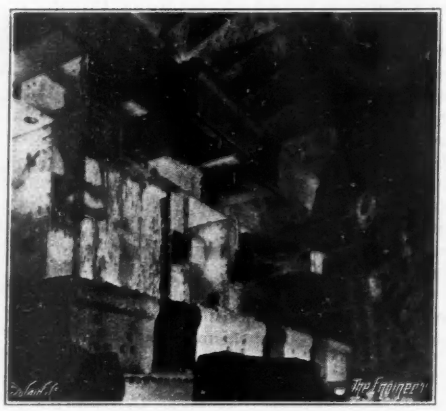
AKROYD STUART AWARD PAPER, 1938–39.—The Council of the Institute of Marine Engineers asks us to publish the following announcement:—The attention of the Council of the Institute of Marine Engineers having been drawn to the fact that an appreciable portion of the Akroyd Stuart Award Paper, 1938–39, by S. N. Mukerji, M.Sc., A.M.I.E. (India), on "The Origin and Development of the Heavy Oil Engine," was a reprint, without comment or analysis, from two publications of another author in the "Proceedings" of the Institution of Mechanical Engineers for 1932 and 1939, the matter was referred to Mr. Mukerji, who regrets that he omitted to include an explicit statement to this effect in his essay and now makes full acknowledgment.

Queens Midtown Tunnel, New York

No. II

(*Continued from page 493, May 31st*)

PROPER evaluation of the work that was done in driving the two tubes with four shields beneath the East river requires that one should have some knowledge of the radical differences between the beds of the Hudson and East rivers. It has been appropriately said that the Queens Midtown tunnel is the largest tunnel of its kind ever attempted in difficult ground in the United States. Thomas W. Fluhr, assistant geologist, Board of Water Supply of New York City, has made the difficulties of the task clear. As he explains: "In the Hudson river, tunnels penetrate glacial deposits only at the east and west shores. The material encountered under the river itself is river silt of recent origin, which is not very compact and is easily displaced. In the East river the deposits of silt are relatively unimportant and much of the tunnel has been driven in coarse and compact glacial deposits. There is another difference. The rock gorge in the Hudson river is wide and deep. In the East river, there are two rock gorges, which are shallow and not very wide. Since this is so, the tunnel in the East river has had to penetrate rock for a much greater distance. However, since the rock gorges are shallow, the rock floor does not fall off so rapidly in elevation as in the Hudson river, and the tunnel has therefore been carried for a greater distance in mixed face—that is to say, unconsolidated material in the upper part of the tunnel with rock in the lower part. Much artificial fill has been deposited in both the Hudson river and in the East river, especially in close to the shores. In the Hudson river this fill sinks down into the river silt, which surrounds the artificial fill and closes the voids in it. In the East river, the artificial fill cannot sink into the compact glacial deposits; and for this reason this artificial fill is much more open and pervious. When attempt is made to excavate this material in compressed-air tunnel work, the air blows out through the voids and sawdust and clay must be used to pack the openings."



FACE OF ONE OF THE SHIELDS

Despite the wide variations in kind and quality of the materials encountered, the Queens Midtown tunnel was driven with commendable despatch beneath the river, although the resourcefulness of the contractor, the courage and determination of his men, and the co-operative skill of the engineers of the Authority were taxed to the utmost at some of the stages of the job.

The two river tubes were driven under the largest contract in connection with the project, officially known as Contract No. 4, embracing a section of the undertaking 4100ft. long between limits. The contract was awarded the Walsh Construction Company, and work was started on July 9th, 1937, under the direction of John S. Macdonald, chief engineer of that company. The contract, which will involve estimated outlays totalling 22,112,000 dollars, includes the complete construction of the long tunnel section—that is, the concrete lining and all other permanent features of the finished tubes, but does not embrace paving, electrical work, the tile-wall finish, and pumping, and operating equipment.

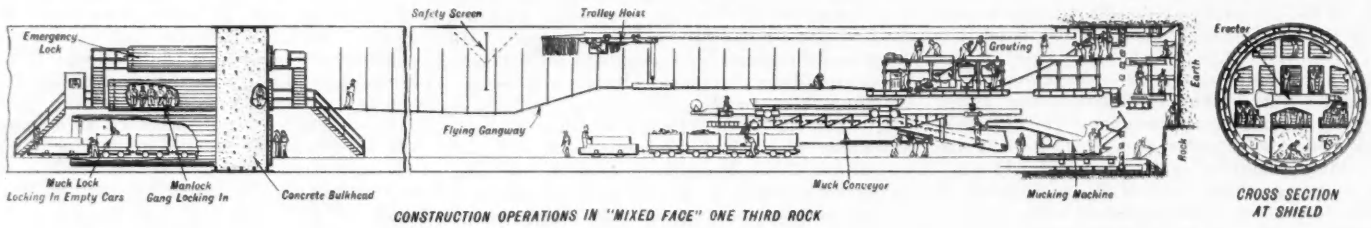
Under Contract No. 4, two shield headings were driven eastward from construction shafts in Manhattan between East 41st and 42nd Streets, east of First Avenue, and two shield headings were driven westward from construction shafts on Borden Avenue, in Long Island City—the distance between the opposed shafts being about 4000ft. The rock penetrated was variously Manhattan schist, a coarse crystalline limestone, and a locally well-known gneiss. The degree of hardness varied widely and the condition of the rock penetrated was anything but uniform. In some places, there were zones of crushed and disintegrated rock, and in many places the upper part of the bedrock was weathered and softened. In the soft ground, the shields encountered diversified assortments of sand, gravel, boulders, riprap, &c. As a consequence, penetration was through full rock face, mixed face, and soft ground—each presenting its own problems to the shield workers. Realising the diversified conditions that would probably have to be met, the contractor employed shields capable of dealing with any one of them. Success or failure depended fundamentally upon the fitness and adaptability of the shields.

Each shield unit had an outside diameter of 31ft. 8in. and an overall length of 18ft. 8in.; and when fully equipped it weighed approximately 325 tons. The outer shell of a shield was 3in. thick, and formed of laminated steel plates fastened together with rivets which were countersunk and ground flush on the outside surface in order to minimise friction resistance. The cutting edge at the front of a shield was composed of heavy cast steel segments; and the upper half of the cutting edge projected 2ft. 10in. beyond the lower half so as to serve as a protecting hood under which the men at the face could work with relative security.

The internal bracing of the shell was so arranged as to afford as much open space as possible through the shield to provide access to the working face and to allow for the removal of excavated material. The largest of the openings, in the lower half of a shield, was of a size that would allow for the passage of a power shovel to handle material excavated at the face. At various levels, and built into the bracing, there were on the front of the diaphragm a number of movable platforms and face jacks hydraulically operated, which could be extended or retracted, as desired, and which served either to support working platforms or to back up breast boards when holding soft ground. Each shield, of course, was equipped with a hydraulically actuated erector arm for handling the cast iron lining segments when pushing them into place for bolting together to form a lining ring. For forcing the shield ahead at each shove, it carried twenty-eight 10in. hydraulic jacks arranged uniformly around a steel ring girder built into the bracing at the rear end of the shield. Each jack was of 200 tons capacity when operating under the usual hydraulic line pressure of 5000 lb. per square inch. When attacking a rock face, automatic drifter drills were carried on drill columns or hand-operated jackhammers were used. Jackhammers, pneumatic chippers, paving breakers, and air-driven spades were variously used when disposing of lesser volumes of rock or contending with relatively softer material. Breast boards were required in much of the ground under the river; and excavating under that condition was unavoidably tedious and at times hazardous.

Work in progress is illustrated by engravings herewith and on page 516.

(*To be continued.*)



DIAGRAMS OF TUNNELLING OPERATIONS

Effect of Coal Characteristics on Pulverised-Coal Firing*

BY OLLISON CRAIG†

COAL is burned in a furnace for the purpose of generating heat which, in turn, is to be transmitted to heat-absorbing surfaces for the purpose of generating steam. While steam generation is the primary purpose, it is also desirable that the generation be as efficient as may be economical, that the equipment be kept in service as continuously as possible, and that the operation be trouble free. When coal is burned in pulverised form in a furnace, that portion of overall boiler efficiency for which combustion is responsible is high when carbon loss is kept at a minimum, when the CO_2 or excess air is maintained within predetermined limits, and when combustion as defined by this carbon loss and this excess air is completed, within the limits of the furnace volume. Continuous and trouble-free operation is had if ignition is maintained constant and steady, and if molten ash in the form of slag does not accumulate in any portion of the furnace or on boiler heating surfaces to such an extent as to interfere with efficient operation.

Carbon loss, excess air, and slag are affected by the characteristics of coal being burned, the design of the furnace, the design of the burners, and the characteristics of the pulverisers.

It is the purpose of this paper to discuss how coal characteristics can affect carbon loss, excess air, and slag, rather than to discuss furnace design, burner design, or characteristics of pulverisers. However, all these factors are so interrelated that it becomes necessary to touch at least briefly on them in discussing the effect of coal characteristics.

The characteristics of coal which affect the burning of coal in pulverised form and affect the results which are obtained from pulverised coal firing are: Volatile matter, fixed carbon, agglutination, swelling, ash, ash-fusion temperature, moisture, sulphur, and grindability.

VOLATILE MATTER AND FIXED CARBON

Bituminous coals, in general, vary from 15 to 40 per cent. in volatile matter. Coals containing less

* The American Society of Mechanical Engineers, Fuels Division, Worcester, Mass., May, 1940.

† Riley Stoker Corporation, Worcester, Mass.

than 22 per cent. volatile matter are classed as low volatile. Coals containing from 22 to 31 per cent. volatile matter are classed as medium volatile. Coals containing more than 31 per cent. volatile matter are classed as high volatile. When high-volatile coal is burned in pulverised form, volatile gas is first distilled and burned, leaving fixed carbon for final combustion. Such coal will burn out more quickly and more completely than would be the case with low-volatile coal, provided all other conditions are the same. If a high-volatile coal, containing 30 per cent. volatile on a moisture and ash-free basis, is burned, then for each pound of combustible matter introduced into the furnace there is 0·3 lb. of volatile gas produced and 0·7 lb. of fixed carbon remaining. If a coal, containing 20 per cent. volatile matter on a moisture and ash-free basis, is burned, there is then 0·2 lb. of volatile gas released for each pound of combustible and 0·8 lb. of fixed carbon remaining. Since volatile gas distills and oxidises quite rapidly, the length of time to complete combustion to the point where there is a predetermined amount of unconsumed carbon remaining in the ash is less in the case of high-volatile coal than in the case of low-volatile coal, since there is a less amount of the slow-burning fixed carbon. The effect of a greater amount of volatile matter in coal on the determination of furnace volume, or conversely, heat release per cubic foot, is to require a smaller furnace volume, provided the size of the furnace is not dictated by other considerations. If furnace volume is established, then the loss due to unburned carbon in ash will be less with high-volatile than with low-volatile coal, assuming the coal to be ground to the same fineness and that all other conditions are constant.

High-volatile coal, then, has an advantage in regard to time necessary for completion of combustion.

Quick ignition and stability of ignition are of much importance in pulverised coal firing. The more quickly ignition can take place, the less time will be required for completion of combustion within the confines of the furnace and the less will be the carbon loss. Stability of ignition and maintenance of flame are necessary for the prevention of explosive puffs in a furnace. Ignition and stability of ignition are dependent on velocity of flame propagation in a mixture of pulverised coal and air, on the temperature at which heat may be radiated to the incoming mixture, and on the temperature in the region through which the mixture passes before leaving the furnace.

Pulverised high-volatile coal, when mixed in suspension with air and ignited, has a higher velocity of flame propagation than is the case with low-volatile pulverised coal. High-volatile pulverised coal which is low in ash and which is mixed with the proper amount of air, may have a flame-propagation velocity as high as 2800ft. per minute. With low-volatile pulverised coal this velocity may be less than 1000ft. per minute. If the velocity of flame propagation of a coal and air mixture being introduced into a furnace is low, then the velocity of discharge of this mixture and the velocity of the secondary air which may be admitted at the burner must also be low to permit ignition and to prevent extinguishing the flame, which may occur in about the same manner that a match can be blown out. Coal mixtures in which the velocity of flame propagation is high ignite more quickly and produce a flame which is much more stable. A wider range of operation can be had with mixtures having higher velocities of flame propagation since ignition can be maintained over a wider range of velocities of discharge from the burner. Higher-volatile coals then have an advantage in respect of quick ignition, stability of flame, and wide range of operation in so far as range of operation is dependent upon ability to maintain flame.

Quicker ignition and better flame stability are obtained with high-volatile coal for another reason. A mixture of coal and air must be heated to the temperature at which the coal will ignite. This requires a source which can supply heat to the incoming coal and air. More volatile gases are distilled from high-volatile coal and produce a zone of higher temperature in the region near the burner from which heat can be radiated to the incoming fuel and air. This gas flame is then the source of heat igniting the incoming coal.

Present-day practice is to design furnaces which are almost completely lined inside with water-cooled metal surfaces. The average temperature in such furnaces is obviously lower than it is in all-refractory furnaces. Experience has indicated that if pulverised coal, either high volatile or low volatile, is burned at a given rate in an all-refractory furnace, the loss due to unburned carbon is less than it would be if the same coal were burned at the same rate in either a partially or completely water-cooled furnace. This fact would indicate that water-cooled surfaces in a furnace tend to retard combustion of fixed carbon. It might be considered that this could be compensated for by burning coal at a greater rate in a water-cooled furnace and thereby raise the average furnace temperature. However, this does not accomplish the purpose, since with an increased rate of coal burning, a particle of coal is in the furnace for a shorter time and as a result the fixed carbon is less completely burned. Other means can be taken partially to compensate for the cooling effect of water-cooled furnaces. Coal and air can be introduced by means of multiple burners in such a way as to produce more turbulence in the furnace. The scavenging action resulting from increased turbulence will result in more complete combustion of fixed carbon and will thereby at least partially compensate for the slower burning effect produced by lower furnace temperature. Here, again, high-volatile coal has an advantage, since it is not so greatly affected by the cooling action of water-cooled furnace as is low-volatile coal. Again, experience shows that if a high-volatile coal is burned in a water-cooled furnace at a given rate, the loss due to unburned carbon is less than when burning low-volatile coal in the same furnace at the same rate.

The difference is so pronounced that it frequently becomes necessary to make corrective modifications in the case of water-cooled furnaces when low-volatile coal is burned. One method of accomplishing this is to reduce the rate at which heat is absorbed by water-cooling surfaces in the furnace. This may be done in the original design by the application of heat-retarding blocks or refractory material to the surface of furnace water tubes, or it may be done later, after experience with operation has indicated the necessity, by the application of refractory material over the surface of the water tubes, this refractory material being applied on those areas of the furnace walls on which it may be the most effective. These areas are usually in line with the burners on the side walls and in some cases on the rear wall and extend a few feet above and below the centre line of the burners.

The effect of the application of such heat-retarding material is most strikingly illustrated in the case of burning petroleum coke. Petroleum coke usually has less volatile matter than does even low-volatile coal. The volatile matter of petroleum coke may be from 7½ to 20 per cent., and is usually below 15 per cent. It is almost impossible to ignite and maintain a stable flame with this material in an entirely water-cooled furnace. Recently, an oil refinery started burning pulverised petroleum coke in furnaces of existing boilers. The furnaces were originally built for oil firing and later were modified for firing pulverised Mid-Western coal by the application of waterwalls to the side walls and rear walls. These furnaces had less cooling than they would have had if they had been designed for use with pulverised Mid-Western coal. When pulverised petroleum coke was first burned in these furnaces, the fly-ash loading of gases leaving the boilers was excessive and the carbon content of this fly ash was quite high. A 10ft. belt of refractory was placed on each side wall, the centre of this belt being in line with the centre line of the horizontal burners. Later a 10ft. belt was placed on the rear wall. With this refractory on the side walls and rear wall, half the waterwall area in each furnace was covered with refractory extending 2½in. beyond the surface of the tubes. Before refractory was applied, fly-ash loading in stack gases at about 400 deg. Fah. was from 3 to 6 grains per cubic foot and the carbon content of this fly ash was from 96 to 97 per cent. With refractory on the side walls, fly-ash loading in the gases was reduced to 1·25 to 1·5 grains per cubic foot, and the carbon content to a range of 88 to 92 per cent. With refractory on three walls, the fly-ash loading dropped to 0·3 grain per cubic foot and the carbon content to a range of 70 to 75 per cent. The carbon content in the fly ash is apparently high, but the original coke contained only 0·7 per cent. ash. This experience illustrates, in possibly an exaggerated form, the necessity for compensating for the low-volatile content of pulverised coal.

Practical considerations dictate the necessity of constructing pulverised coal furnaces with surrounding walls which are composed almost completely of water tubes. With such furnaces, high-volatile coal has an advantage as compared to low-volatile coal, in initial ignition, stability of flame, and carbon loss. This requires that in such furnaces, where low-volatile coals are to be burned, something be done in order that the low-volatile coal can be burned with the same effectiveness as high-volatile coal. This usually means the application of heat-retarding material to the water-cooled surfaces. In some cases this can be sufficiently accomplished by the accumulation of ash on the surfaces of furnace wall tubes. In other cases, it becomes necessary to apply refractory or some form of blocks.

In the design of a new boiler unit it is well to consider whether high or low-volatile coal will be burned, what range of load will be required, and what provisions will be required in furnace wall design in order that the selected coal may be burned with the best results.

Agglutination

Certain kinds of coals have a tendency to cake. These are called "caking coals," and this caking property is called "agglutination." When such coals are burned on grates or on a stoker, the effect of this property is to produce a fuel bed condition in which coal particles and lumps adhere to each other in such a way as to be largely impervious to the passage of air. Some form of agitation is necessary to break up these cakes of fuel in order that air can have access to the surfaces of coal particles. Similar adherence of particles occurs when this same kind of coal is fired in pulverised form. A large number of separate and individual particles, which have been reduced to an extremely fine state in a pulveriser, can, when subjected to heat in the furnace, collect and adhere together so as to form an individual mass. The result is the same as if coal were introduced which had been quite coarsely ground. The effect of agglutination, when coal is fired in pulverised form, is to increase the loss due to unconsumed carbon, because these accumulated masses cannot become as completely burned in the time of passage through the furnace as can the smaller individual particles.

Swelling

Certain bituminous coals swell or increase in volume when subjected to heat. If such a coal is pulverised and introduced into a hot furnace each coal particle swells. Since each particle increases in volume with no increase in weight, it is carried more rapidly by the gas stream and is in the furnace a shorter time. The result is increased carbon loss.

Ash

The amount of ash in coal will vary from 5 per cent. in some Eastern low-volatile coals to 20 per cent. in some low-grade Mid-Western coals. The effect of a greater amount of ash in pulverised coal is to reduce flame velocity in a mixture of coal and air and, as a result, to interfere with ignition and flame stability.

The minimum rate at which high-ash coal can be burned in a furnace with continuous firing is greater than with a coal having a less amount of ash, but the same volatile.

Experience seems to indicate that it is possible to operate with as low percentage of excess air with a high-ash Mid-Western coal as with low-ash Eastern coal and also that with this same percentage of excess air the total loss due to unburned carbon is about the same. In order that the total loss due to unburned carbon be about the same with the high-ash Mid-Western coal, it is necessary that the percentage of carbon in ash and refuse be less than in the case of low-ash Eastern coal. This is apparently true. This seems to come about through the fact that, first, larger furnaces are usually provided for a given rate of coal burning when the coal contains high percentage of ash with a low temperature of fusion; and secondly, Mid-Western high-ash coal is usually more free burning and the fixed carbon is burned more rapidly.

Ash Fusion Temperature

Coal ash will fuse at temperatures ranging from 1800 deg. Fah. in the case of Mid-Western coals to 2800 deg. Fah. in the case of good-grade Eastern coals. Softened or molten ash will adhere to furnace surfaces, furnace outlets, and heating surfaces of boiler and superheater.

Fused ash which deposits in the furnace causes increased refractory maintenance and interferes with ash disposal. Fused ash which deposits on boiler and superheater surfaces reduces heat absorption and closes off gas passes, in some cases to such an extent as to require the boiler to be taken out of service.

If sufficient water-tube surface is exposed to radiation from the furnace, fine ash particles may be reduced to less than fusion temperature before entering the tube bank. If, in addition, such refractory surfaces as may be in the furnace and also the ash outlet from the furnace are kept a sufficient distance from the flame, no trouble will be experienced by slag accumulation on furnace walls or by slag blocking the ash outlet.

Average furnace temperature can be reduced by burning coal with a greater amount of excess air, at the expense of boiler efficiency. This is frequently resorted to when coal must be burned having ash with lower fusion temperature than was contemplated when the furnace was designed.

Moisture

The high moisture content of coal affects the performance of a pulveriser; it tends to reduce capacity and fineness of pulverisation, and it increases the power required. The immediate effect of moisture in pulverised coal after it is introduced into a furnace is to interfere with ignition. Coal particles must receive sufficient heat to be brought up to ignition temperature. If there is water in the coal particles this water must first be evaporated. This means that more heat must be received by a coal particle to bring it to ignition temperature. After the water has been evaporated the vapour then probably acts as a diluent to the volatile gases and retards combustion in much the same way that ash does. Any water that is contained in pulverised coal carries away from the boiler a certain amount of the heat which it receives in the furnace, and to just that extent reduces the overall efficiency of the steam generating unit.

However, it is possible that a certain amount of water in at least certain kinds of coal may so affect the process of combustion as actually to result in an increase in the efficiency of the steam generating unit. This would have to come about through a reduction in unburned carbon or through an ability to operate

with less excess air with the same unburned carbon. Tests have been made which have indicated this to be true with certain Mid-Western coals. It is well known that with Mid-Western coals an increase in moisture content will, to a considerable extent, increase overall efficiency when a boiler is fired by means of an underfeed stoker, and it is also known that this is true when a boiler is fired by a travelling grate stoker, except that in the case of the travelling grate stoker there is a lower limit to the maximum moisture content which will produce maximum efficiency. It is also known that it is almost imperative to have more than a normal moisture content with certain caking Eastern coals, if these are to be successfully burned on a travelling grate stoker. The action of moisture in coal which produces these results in the case of stoker firing may or may not be similar to the action which occurs in the case of pulverised coal firing. It might seem, however, that, at least with certain kinds of coal, there could be some amount of moisture in coal particles which, in the process of evaporation and expansion, could leave the coke particle in such a condition that it would be more capable of combining with oxygen.

The effect of unusual moisture content, however, is to interfere with ignition, and stability of flame, and to cause erratic combustion and increase in carbon loss.

Usually it is not economical to dry coal which is to be pulverised in a direct-firing system. If the coal is dried, heat must be supplied for evaporating the moisture in any case. Unless this heat is supplied from waste heat leaving the boiler the cost of the heat for drying may be greater than the loss in heat carried away from the boiler in the vapour.

Sulphur

The sulphur content of coals varies through a wide range and may be as low as ½ per cent. and as high as 5 per cent. Sulphur in coal usually occurs in the form of iron pyrites. A large amount of sulphur is usually an indication that the ash fusion temperature is low and that trouble will be experienced both from slag resulting from this low ash fusion temperature and from the effect of the iron which is combined with the sulphur in iron pyrites.

Grindability

Grindability is a measure of friability, or the ease or difficulty with which coal can be reduced to a fine state. Coal which has a high grindability is more easily pulverised, and coal which has a low grindability is pulverised with greater difficulty. There are a number of indexes which give a measure of the grindability of various coals. Any index is usually expressed in terms of a numerical value, and 100 on a chosen scale represents a certain grindability which is used as a measure of comparison. A coal which has a grindability of 50 in terms of some index is more difficult to pulverise than a coal which has a grindability of 100. All types of pulverisers will have less capacity with coal of low grindability than with coal of high grindability. At the same rate of grinding in terms of pounds of coal per hour, and with the same power input, coal of low grindability will be pulverised to a less degree of fineness than will be the case with coal of high grindability. There is a broad relation between volatile matter of bituminous coal and grindability. In general, low-volatile Eastern bituminous coals come within the high-grindability range, while high-volatile Eastern bituminous coals come in a low-grindability range. Coal having from 15 to 25 per cent. of volatile will generally fall within the range of 90 to 100 grindability, while coal having 30 to 35 per cent. volatile will generally fall within the range of 50 to 65 grindability. Mid-Western coal, with the same percentage of volatile as high-volatile Eastern coal, will usually have somewhat higher grindability than Eastern coal. It seems fortunate that low-volatile coal does have high grindability, since, with the same pulverising equipment, it can be reduced to a finer size, and a finer size tends to compensate for the effect of lower percentage of fixed carbon. By the same reasoning, it is not necessary to pulverise high-volatile coal to the same degree of fineness as low-volatile coal, since there is less fixed carbon to be burned. In the case of Mid-Western coal it is possible to pulverise it with still less degree of fineness, since this coal has a property which is referred to as "free burning." A free-burning coal is one which has practically no caking tendency and in which the free carbon is apparently so disintegrated and broken up in the process of volatile distillation that there is ready access of oxygen to a greater surface.

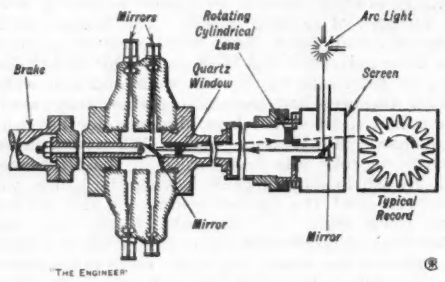
It might seem from this discussion that all the advantages are with high-volatile coal in pulverised coal firing. Such is not the case. Low-volatile coals have certain definite advantages. Low-volatile coal is usually more friable. This results in a lower purchase price for equipment, less power to operate, and less expense for maintaining pulverising equipment. Low-volatile coals average higher in heat value, so that less weight of coal is required to generate a given amount of steam. The ash from low-volatile coal usually fuses at a higher temperature, so that less boiler and furnace maintenance is required and boilers may be kept in operation longer periods of time.

In any locality some type of coal is usually most available and most economical to use. In other localities a wider choice of coal may be had, and at one period of time coal of certain characteristics may be the most economical while at another period coal of quite different characteristics may be the most economical. By giving proper consideration to the characteristics of coal or coals most available and most economical to use, designs can be made which will take advantage of those characteristics which may be considered good and which will lessen or eliminate the effect of those which may be considered bad.

Turbine Blade Vibration

Difficulties experienced with early American superposed turbo-electric generator sets indicated the need for a better understanding of the conditions affecting the operation of turbine impulse blades. To obtain good economy, at partial loads, the incoming steam is fed to the first turbine wheel at a portion of its periphery, and the blades passing into and out of this steam jet receive a violent shock at each revolution of the turbine. But it has only been on those few machines of the large superposed class, operating at a pressure of approximately 1200 lb. per square inch and at a temperature of about 900 deg., that the system has caused some of the blades to break at the root where they are fastened to the spindle.

To enable the behaviour of the turbine blades to be studied directly an optical method has been devised, whereby engineers can see inside the turbine while it is running and observe the blade vibration. As shown in the accompanying diagram, taken from *Electrical Engineering*, published by the American Institute of Electrical Engineers, minute mirrors are mounted inside the blades, and a light beam, projected through a hole in the turbine shaft, is reflected by an inclined mirror through a hole in the spindle and blade to the mirror in the whirling blade under



BLADE OBSERVATION APPARATUS

investigation and then back out through the shaft to a stationary camera or viewing screen.

By taking pictures at short intervals on a moving film an exact record of blade performance may be obtained for any desired set of operating conditions. As shown by the typical record at the right of the diagram, the vibration of the blade is indicated by the oscillation of the light spot reflected back from the turbine blade around a circular path. If there were no vibration the pattern would be a perfect circle.

An experimental turbine constructed on these lines by the Westinghouse Electric and Manufacturing Company has been under test in the South Philadelphia works of the company for some months, and more than 20,000 photographic records have been obtained showing the performance of impulse blades for a wide range of operating conditions, the machine operating at a pressure of 400 lb. per square inch and 600 deg. Fah.

It has been found that the load on the turbine has relatively little effect on the maximum blade stress. The factors that influence this condition are mechanical resonance and the damping characteristics of the blade steel. Experiments have shown that the impulse blading of large superposed turbines must be designed to operate at safe stresses under resonant conditions. Damping characteristics of different steels vary widely. The extensively used 12 per cent. chrome steel has more damping in its range of application than any other material so far investigated. Materials of the chrome-nickel class that excel in high strength at high temperatures have about one-tenth as much damping as 12 per cent. chrome steel. As the frequency of vibration increases damping becomes less, which means that the increased stiffness of heavier blades does not result in much lower blade stresses. At the higher operating temperatures damping decreases rapidly, particularly beyond 750 deg. Fah.

Successful results obtained with the first machine led to the construction of a larger experimental unit with a full-sized impulse wheel; that is, a duplicate of the first impulse stage of a 50,000-kW superposed unit, operating at a pressure of 1250 lb. per square inch and a temperature of 900 deg. Fah. With its 10,000-kW generator and 15,000-H.P. water brake this machine began testing operations in February at the Schuylkill plant of the Philadelphia Electric Company.

The turbine takes steam from the station high-pressure mains and exhausts into the low-pressure mains, thus permitting of its operation as a superposed unit without interference with the station's regular working. Built solely for research purposes, the turbine has many special features. The optical-system will record the performance of sixteen different blade combinations and two rotors are being built with different blade designs. The use of the 10,000-kW generator will permit of life tests on the turbine blading by loading the machine on the Philadelphia Electric Company's system.

American Engineering News

American Train-Ferry Steamer

The latest addition to the fleet of nearly two dozen train-ferry steamers operated on the Great Lakes by a number of railway companies will be put into service on Lake Michigan in June. In the United States these vessels are commonly called car-ferry steamers as trains are rarely carried. This new boat, which is the largest and most powerful of its type on the Great Lakes, is being built for the Pere Marquette Railroad, which will then have ten such vessels in operation across the lake, a distance of approximately 85 miles. Like its predecessors, it is specially designed as an ice-breaker. It is 410ft. long, 57ft. beam, and 23½ft. deep below the main or car deck, with a mean loaded draft of 17ft. 6in. Turbo-electric power equipment of 6500 shaft horse-power drives twin screws and will give a sea speed of 18 m.p.h. The hull has ten watertight compartments and reinforced double bottom. Steam is supplied by water-tube boilers. Four lines of rails on the main deck have capacity for forty long double-bogie 100-ton freight cars. On the upper deck space is provided for fifty automobiles or other motor vehicles, since there is a large tourist and commercial traffic across the lake. The gangways will be approached by ramp at the terminal berths. Railway cars will be moved on and off the slip at the stern, a hinged double-track landing span connecting the shore tracks with those on the steamer. In the superstructure will be the saloons, dining-room, 74 state-rooms, and other passenger accommodations, including 12 parlour suites. Air-conditioning service is applied to all the cabins. Two other vessels of this railway's equipment have turbo-electric drive and water-tube boilers, with machinery for crushing, storing and feeding the coal to the furnaces. Practically all the others have twin screws with triple-expansion engines.

Shipyard for Welded Vessels

A recent development in the American shipbuilding industry is the completion of the new Ingalls shipbuilding works situated on the Gulf coast and designed specially for the construction of large welded ships. It is already at work on eight cargo ships of 8500 gross tons for the American Maritime Commission. Of thoroughly modern design throughout, it has long open shops and large erection platforms, and special types of tools, equipment, material handling facilities, cranes, &c. The plant occupies a 50-acre site with nearly a mile of water front. The two-storey mould loft has plate and shape storage, and laying-out tables, served by 15-ton bridge cranes. At right angles to it is the plate and angle shop, with overhead cranes and a petrol locomotive. It has the heavy machine tool equipment, arranged for straight-line movement, and houses an assembly platen 150ft. long and 35ft. wide. There are no punches, but burning tables for bevel burning. Manual welding with portable machines on the platens permits welding to proceed as soon as the plating is assembled. Automatic power welding machines are also provided. The furnace and forge shop has angle and plate furnaces served by overhead travelling cranes. All heavy machines are served by 5-ton electric jib cranes. In the power house is a compressor of 500 cubic feet per minute, to serve the pneumatic tools. Five building ways of reinforced concrete are built, with a slope of ⅝in. to the foot; the launching ways are extended to a depth of 30ft. at low water. The ways are served by 35-ton revolving cranes on travelling gantry towers 66ft. high, with electric drive on a track of 20ft. gauge. The plant includes a welding school and has a personnel department which selects employees for training. With absence of reaming and riveting machines, the work is practically noiseless, while the erection work is cleaner and there is less debris in the form of lost bolts, nuts, washers and rivets, and also ashes from rivet heaters. It is estimated that a ship can be built in much less time by welding.

Lubricating Oil Barrels and Drums.—In order to facilitate the distribution of lubricating oil throughout the country, the Secretary for Petroleum requests that, where proper storage exists, all lubricating oil barrels, both steel and wood, and drums should be emptied at once and returned to the oil companies that made the deliveries. Oil containers must not be used for other purposes, nor disposed of in other directions, nor should they be retained any longer than is necessary.

Rail and Road

MOTOR FUEL RATIONING.—The Secretary for Petroleum announces that he has made an order, the Motor Fuel Rationing (No. 2) Order, 1940, which came into force on June 1st, 1940. The purpose of the order is to strengthen and clarify the provisions of the order made in September last, which it supersedes.

WORKMEN'S TRAINS ON SUNDAYS.—It is announced by the Ministry of Transport that the Railway Executive Committee has arranged that, as a war-time emergency measure, workmen's tickets will be issued at any time on Sundays for journeys between places of residence and places of employment to all applicants producing a works pass, shift certificate, or other means of identification associated with the place at which the work is to be performed. The arrangements began on Sunday, June 2nd.

RAILWAY WAGES.—On Friday last, May 31st, it was officially announced that the Railway Executive Committee and the three railway trade unions have agreed to an increase of 3s. a week on the war wage paid to adult males in the traffic grades. The settlement also provides proportionate amounts to juniors and females, and an increase of £8 per annum for the adult male clerical staff. The increases will operate as from Monday last. The unions, we may recall, made an application for an increase of 6s. The Associated Society of Locomotive Engineers and Firemen, which met at Southport on Saturday, June 1st, accepted the award, and the National Union of Railwaymen approved the terms on Friday. The Railway Clerks' Association will also approve the terms.

NEW PULLMAN COACH SLEEPING CARS.—According to the *Railway Age*, two experimental Pullman convertible day coach sleeping cars are, during the present month, to be run over various lines in the United States. Each of the cars has a side gangway and ten seating and sleeping sections. Five of the sections have accommodation for six passengers, and the other five for three passengers in each day and night. The daytime accommodation accords with the best *de luxe* coach comfort and has seats with adjustable height, slope, and arm and footrests. At night the vehicle is converted into a side corridor ten-compartment coach. The cars are air conditioned and the air inlets to each compartment are individually controllable. Individual lighting and reading lamps are also provided.

LEARNER-DRIVERS.—The Minister of Transport has made a regulation temporarily removing the requirement that holders of provisional licences must be accompanied by a fully licensed driver, and that a vehicle must carry "L" plates. It may be necessary without notice to suspend again for a time the official driving tests, owing to transfer of driving examiners to more urgent national service. Tests already arranged will be carried out as far as possible, but may be subject to considerable delay. The new regulations relieving the holders of provisional licences from the requirement as to supervision will, however, enable those who find it necessary to drive to do so even if they have no opportunity to take the driving test, and may ease the position if there is a scarcity of available drivers.

ROAD WORK IN GLOUCESTERSHIRE.—On Monday, May 27th, the Gloucestershire Highways Committee considered a suggestion from the local branch of the Farmers' Union expressing an opinion that by ceasing to carry out any unnecessary work on the roads money would be saved and labour released for agricultural work. It was stated by the Chairman, Major J. H. Dent, that the question of the work on roads had been carefully reviewed by the Committee, and that the county surveyor would shortly present a report, which, if carried out, would result in a decrease of expenditure of about £30,000. Since the outbreak of war, the number of men employed on the road staff had fallen from 2000 to 1950, and it was estimated that a further 500 men would be called up during the next three or four months.

AN L.M.S. SALVAGE CAMPAIGN.—A salvage campaign has been initiated by Lord Stamp throughout the whole of the L.M.S. system. At each of the 2400 passenger stations and 2900 goods depots, at marshalling yards, and at engineering works, receptacles are being provided for the collection of usable waste. Central dumps are being established to facilitate accumulation and sorting, and to provide an easy channel for disposal. Iron railings around railway houses are being removed, as well as those around other railway properties. Consideration is being given to the cutting down of trees along the side of the line, in order to augment the country's supply of timber. Anti-freeze mixture, of which the L.M.S. railway uses 2000 gallons per year, is to be saved at the end of the winter, and by use of a process of filtration and separation made so that it can be used again the next year.

WIRELESS RECEIVING SETS IN ROAD VEHICLES.—The Postmaster-General announces that a Defence Regulation has been issued in an Order in Council dated May 29th which provides that, apart from certain authorised exceptions, no person shall use or have in his possession or under his control any wireless receiving apparatus installed in any road vehicle. Any wireless receiving apparatus, even if it is not fixed in position—for example, a portable set—will be deemed for the purpose of the Regulation to be installed in a vehicle, if it is in the vehicle in such circumstances that it can be used or readily adapted for use. By a notice in the *London Gazette* dated May 31st, the Postmaster-General has cancelled all ordinary wireless receiving licences for the installation and working of wireless apparatus in road vehicles. In the absence of special authority, therefore, all persons who have wireless apparatus in motor cars or other road vehicles must take immediate steps to remove all such apparatus, including aerials, from these vehicles. This must be done at once, whether the vehicle is at present in use or is laid up. The wireless licences in respect of these vehicles should be retained by the owners. No refund of licence fees can be made, but the question whether any allowance can be made in respect of their unexpired period will be considered when the time comes to remove the present embargo and to issue fresh licences for the use of wireless apparatus in road vehicles.

Miscellanea

LAND DRAINAGE SCHEMES.—The period in which grants are available towards the cost of land drainage schemes in England and Wales has been extended by the Minister of Agriculture and Fisheries, with the consent of Parliament, until July 31st, 1941.

A MINISTRY OF SUPPLY APPOINTMENT.—The Minister of Supply has appointed Sir Walter Layton to be Director-General of Progammes in the Ministry of Supply and to be a member of the Supply Council. Sir Walter Layton was a member of the Munitions Council in the Ministry of Munitions during the last war.

IMPORT OF RUBBER SEALING FLUID.—The Treasury has issued the Import Duties (Exemptions) (No. 3) Order, 1940, which exempts from import duty for a period of one year certain aqueous dispersions of rubber used in the hermetic sealing of cans. The Order came into operation on Thursday, May 30th, 1940.

AN OLD HYDRO-ELECTRIC PLANT CLOSED DOWN.—The turbines installed on the River Kiachnish in the mountains three miles from Fort William in 1896 have been closed down. The district is now being supplied with current by the hydro-electric plant at Lochaber owned by the British Aluminium Company.

INCREASED WAGE BILLS.—The Treasury has been asked to make the following announcement on behalf of the Government:—Owing to the speed-up, with Sunday working, &c., wage bills of contractors and sub-contractors on Government work will naturally be bigger. Firms are therefore advised to make all appropriate arrangements to meet the situation, if necessary in consultation with their bank.

THE TIN QUOTA.—At a meeting of the International Tin Committee held on May 27th the quota for the third quarter of 1940 was fixed at 100 per cent. of the standard tonnages. The Committee recommends to the signatory Governments that export rights at this rate, for the third quarter, should be issued as soon as possible, and that exports against these rights should be permitted, prior to the beginning of the third quarter, but subject to adjustment later against export rights for that quarter.

A NEW ELECTRICITY COMMISSIONER.—The Minister of Transport has, with the concurrence of the Board of Trade, appointed Sir Leonard Pearce, D.Sc., M. Inst. C.E., M.I. Mech. E., M.I.E.E., to be an Electricity Commissioner for part-time duties. Sir Leonard Pearce is the engineer-in-chief of the London Power Company and has previously served as an Electricity Commissioner. He was, we may recall, for many years the Chief Engineer and Manager of the Electricity Department of the Manchester Corporation.

TIMBER PRICE NEGOTIATIONS.—According to a recent order made by the Minister of Supply under the provisions of the Control of Timber Order, prices for home-grown timber may now be negotiated between buyers and sellers, when they are not already fixed by the Control Orders, and also in cases where the prices are already fixed, but in which the timber is of exceptionally large dimensions. In all such cases delivery of the timber may not be made until the negotiated price has been submitted to and approved by the Timber Controller.

THE INSTITUTE OF BRITISH FOUNDRYMEN.—Owing to the gravity of the international situation, and also because so many foundries are endeavouring to operate seven days per week, the annual conference of the Institute of British Foundrymen which was to have been held at Cheltenham on June 7th and 8th has been cancelled. Members of the Institute who have applied for advance copies of the papers will receive them in due course, and written discussion is invited and should be sent to the Assistant Secretary, St. John Street Chambers, Deansgate, Manchester, 3.

THE CANCELLATION OF HOLIDAYS.—The Minister of Labour and National Service, Mr. Ernest Bevin, desires to express on behalf of the Government his deep appreciation of the splendid response of all those engaged in industry to the appeal to intensify production. He urged that this great production effort shall be maintained, especially on urgent national production which has priority, and that the seven-day week should be continued for a time. In order to maintain health and physical efficiency, the Labour Supply Board is applying its mind to suggestions for organising methods of giving rest periods, and advice on this will be issued as soon as possible. In the present grave emergency, production must not be interrupted by holiday periods, especially those for several days at a time which are customary in certain parts of the country during the summer months. The Government therefore asks workers and employers to cancel all such holidays for the time being and to wait further guidance on the subject, which will be given as soon as the situation permits. Every minute spent on production now is vital to the defence of the country and its homes.

WAR-TIME PRODUCTION IN TECHNICAL INSTITUTIONS.—A memorandum issued on Monday, May 27th, by the Board of Education urges technical schools and colleges to assist in the war effort by concentrating on the production of gauges and jigs which are used with vast numbers of machine tools in the armament industry. Without a sufficient supply many machine tools would stand idle. The Board is satisfied that many of the parts required could be manufactured in the workshops of technical institutions, either as exercises for trainees and students, or directly by the college staff, assisted by recruited labour, male or female. Institutions less well equipped could fashion the parts roughly to size, then passing them on to better equipped colleges for finishing. Much of the preliminary work could be done by junior technical students or by semi-skilled trainees. Schools are asked to consider keeping their workshops open after the school work is over for as many hours out of the twenty-four as can be organised. Shifts of workers or evening shifts might be arranged and the workshops run during these periods as a factory. The usual commercial rates will be paid by the Ministry of Supply or other Government department concerned for all that is produced.

Air and Water

THE UNITED STATES LINER "AMERICA."—It is stated that Friday, June 28th, has been provisionally fixed for the entry into service of the United States Liner "America" which is the largest merchant ship built in America.

COASTGUARD CONTROL.—It is officially announced that the Admiralty has made an order under Section 2 of the Coast Guard Act of 1925 transferring from the Ministry of Shipping to the Admiralty the management and control of his Majesty's Coastguard.

AERONAUTICAL AWARDS IN GERMANY.—According to a report from Germany, the Lilienthal Society for Aeronautical Research has recently awarded three Lilienthal memorial medals. They have been bestowed upon Herr Kurt Tank for his engineering work on the Focke-Wulf Condor aircraft; to Dr. Heinrich Klein for his work on aircraft armament with the Rheinmetall-Borsig Company; and to Dr. Friedrich Seewald for scientific work.

MOTORBOAT AND YACHT ENGINEERS REQUIRED.—A number of men with experience in marine internal combustion engines are required for service as enginemen in yachts or motorboats. Also men who have had charge of motorboats and have good knowledge of coastal navigation as uncertified second hands. They should apply in person or in writing to the nearest Registrar, R.N.R., at the Merchantile Marine Office or Custom House, or to the Fishery Officer.

FRENCH NAVAL LOSSES OFF DUNKIRK.—The French Navy reports that 300 French warships and merchant ships of various sizes, as well as 200 smaller boats, along with naval air arm formations, took part in the evacuation of the Allied Armies from Dunkirk. The French naval losses include the destroyers "Jaguar," "Chacal," "l'Adroit," "Bourrasque," "Foudroyant," "l'Ouragan," "Siroco," and the supply ship "Niger." Most of the crews, it is announced, were saved.

AUSTRALIAN AIRCRAFT TRANSFERRED TO BRITAIN.—The Rt. Hon. S. M. Bruce, the High Commissioner for Australia, has informed the Minister of Aircraft Production that the Australian Government proposes to transfer to the British Government its claims upon an important aircraft order now being completed in the United States of America. The Minister of Air Production has gladly accepted the proposal, and has thanked the Australian Government for its splendid act of generosity.

SHIPBUILDING LABOUR.—According to an agreement which has been reached between the Shipbuilding Employers' Federation and the Shipyard trade unions, which is subject to certain reservations to be mutually agreed, if it is apparent that skilled men are not available and production as a consequence may be prejudiced, skilled man power in the shipbuilding industry may be supplemented by the employment of an alternative class of worker on jobs which were previously carried out by skilled men.

SOUTHERN RAILWAY CROSS-CHANNEL STEAMERS SUNK.—With the outbreak of war most of the cross-channel steamers of the Southern Railway Company were fitted out as hospital ships. The Admiralty announces the loss of the "Brighton" and the "Maid of Kent," which were sunk by air attack in the port of Dieppe about a fortnight ago. On Sunday last the "Paris" was bombed off Dunkirk, and was abandoned after being put out of action. The "Worthing," which was also attacked, returned safely to a South Coast port.

IDLE AMERICAN SHIPPING.—Within the last few days legislation has passed the Congress and has been signed by President Roosevelt, which now makes available for charter or sale during the duration of the war more than one hundred of the laid-up ships in the fleet of the United States Maritime Commission. These ships will probably become available as the need for them arises. They will be necessary for the handling of foreign commerce, as a result of the spread of the war to other countries and the uncertainty as to the availability of the merchant ships of those countries.

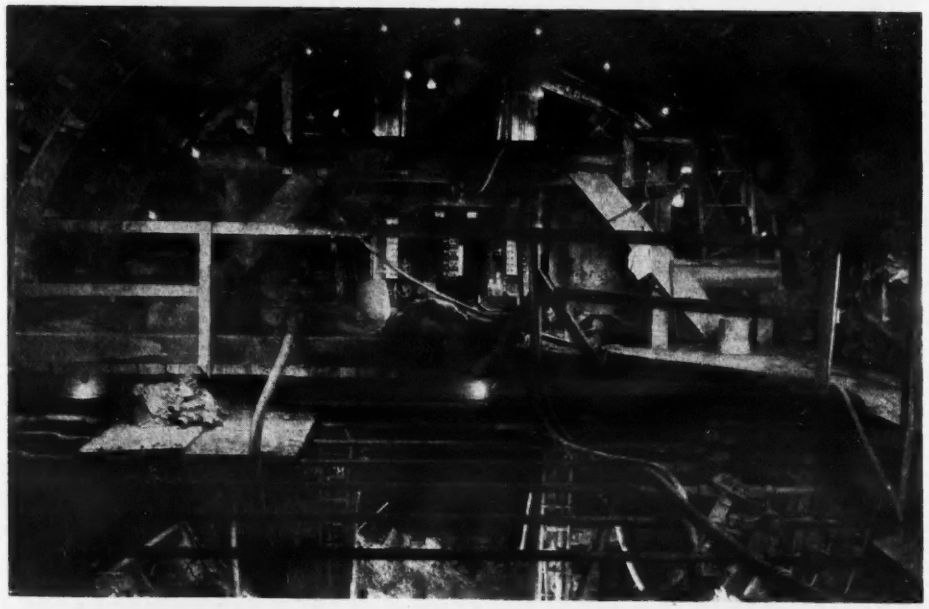
CLYDE STEAMER SERVICES.—The London Midland and Scottish Railway Company announces that certain of the steamer services which it was intended to introduce as from June 1st are postponed until further notice. The temporary cancellations include the additional sailings to and from the Kyles of Bute piers, the services to and from Kilchatten Bay, and connection to Rothesay by the 5.13 p.m. train from the Central Station, Glasgow, and the early morning train from Rothesay at 7.10 a.m. There are also some alterations in the times of sailings to and from Rothesay and Innellan.

AMERICAN AEROPLANE DETECTOR GEAR.—According to a message received from *The Times* correspondent in New York, the United States Army has recently perfected a method of detecting aeroplanes, so sensitive that approaching machines can be picked up at distances more than 50 miles away. It is understood that use is made of light beams, and the method used is capable of being used in any degree of darkness or fog. It is planned to install such detectors in stations along the Atlantic, Pacific, and Gulf coasts of America, and in Hawaii, Alaska, Puerto Rico, and the Canal zone, while four mobile companies are to be set up and equipped to operate at additional stations wherever needed.

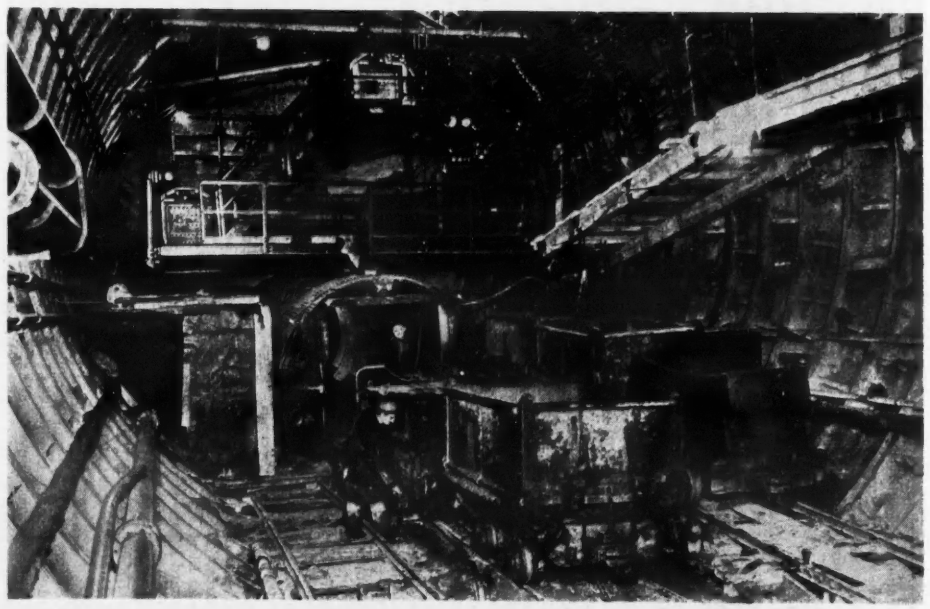
GERMAN SHIPS CAPTURED AND SUNK.—It has been reported that the German tanker "Kattegat," 6031 tons, and ss. "Rosario," 6079 tons, have been sunk by the Norwegians. This brings the total losses of German mercantile shipping up to midnight, May 19th–20th, due to Allied action, to about 830,000 tons, which is now substantially in excess of the total British losses by enemy action. Up to Wednesday, May 22nd, 21,511 British, Allied, and neutral ships had been convoyed in British convoys with a loss of only thirty-one ships, being a loss ratio of one in 694. Neutral ships convoyed totalled 3100 with a loss of only three, representing a loss ratio of one in 1033. The total tonnage of ships convoyed safely to their destination is over 75 million tons, representing a carrying capacity of over 112 million tons of cargo.

CONSTRUCTION OF QUEENS MIDTOWN TUNNEL, NEW YORK

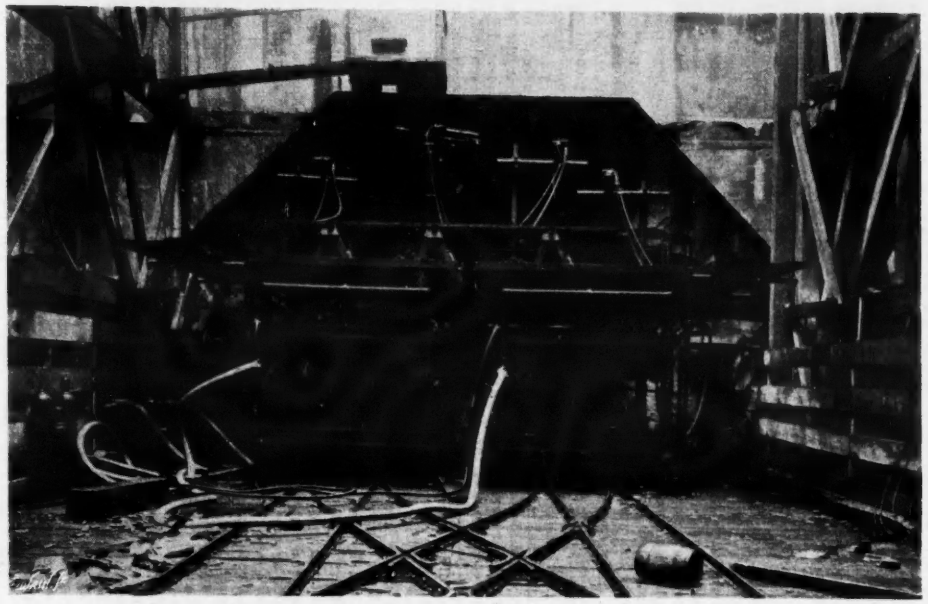
(*For description see page 512*)

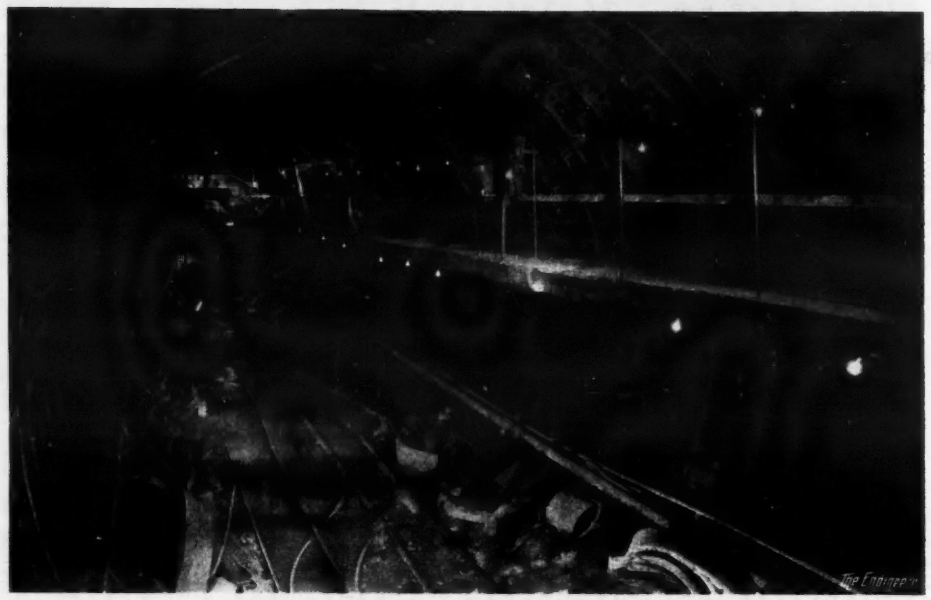


SOUTH TUNNEL—SHIELD IN POSITION TO ERECT RING—AUG. 1938
DRILL CARRIAGE IN POSITION TO START NORTH TUBE HEADING



MUCK CART MOTOR ENTERING MUCK LOCK FROM FREE AIR TUNNEL
NORTH TUBE SHIELD IN POSITION TO ERECT RING





The Engineer

JUNE 7, 1940

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NOTICES TO READERS

IMPORTANT NOTICE

EDITORIAL AND PUBLISHING

The Engineer, which from the end of August, 1939 until the end of May, 1940 was printed by William Clowes & Sons, Ltd., Beccles, is now again being printed by George Reveirs, Ltd., 10, Rosebery Avenue, E.C.1.

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PAPER SUPPLIES

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*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

Postal Address: "The Engineer," 28, Essex Street, Strand, London, W.C.2.

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Telephone: CENtral 6565 (10 lines).

WAR AGAINST A MACHINE

IT was easy to say "This is an engineer's war." We all knew it was. We knew that it had to be fought out with things invented and made by engineers. But even so, we had not grasped the full meaning of what we said. We, in this country, still believed that the "man behind the gun" made so much difference that we could do with less guns than our enemy. Germany has at length opened our eyes to what an engineer's war really is. It is not a war against flesh and blood, but a war against a colossal machine; a machine in which men are accounted no more than the cogs and ratchets of the mechanism. It is ruthless and senselessly destructive because, being a machine, it is without a soul, with no moral sense, with no mind. The whole army of Germany is but a single vast "tank," driven forward at the will of its commanders, but careless of the blood it sheds either of its own people or of others. If we keep that idea in our minds we shall understand its actions better, we shall recognise its weakness, and know what we must do to destroy it. It is the business of engineers to comprehend machines, to recognise their fallibilities, to discover their weak spots, to find out where they are vulnerable. All this they do in peace to improve the products of their hands, but the knowledge can be turned to the contrary purpose. It can be used for destruction instead of construction. It can be employed to put a machine out of gear, to destroy its essential parts, to rob it of those things by which it functions.

Great Britain and that commonwealth of nations which we call the Empire are awake at last. They girded on the sword months ago, but now they have taken up the hammer—the hammer of Thor and Tubal Cain. Responding to the call of a unified Government and submitting gladly to the powers which Parliament gave readily in a few hours to that Government, our workshops and factories and furnaces are working as never before. We have to make a machine more powerful than the machine which is attacking us. And we shall make it. Our strength will wax as that of Germany wanes. The vast soulless machine will be met by a machine as vast, but made ten times as strong by the possession of a soul; of something within ourselves that loves justice and right, and though merciful and compassionate, is relentless in its opposition to ruthlessness and tyranny. That machine will be built because we know now—the experiences of the past few weeks have taught us in bitterness—that this is indeed an engineer's war, a war in which engine has to be set against engine, and mechanism against mechanism, and that the Moloch we are opposing is, in fact, a colossal Robot, which can be destroyed, not by appeals to any of the emotions which move humanity, but only by a machine more powerful than itself.

This idea of the military force of Germany as a machine, and nothing but a machine, enables us to understand much that is otherwise incomprehensible, and with that knowledge and understanding we gain strength. The brutality and ruthlessness, the indifference to life, the stony-heartedness, the plunging forward without reckoning the cost, the overthrow and destruction of things beautiful and revered—all these betray the soulless machine. To rail against it is fruitless; it is deaf, it cannot hear; it has no mind or brain to understand, only an insensate power by which it plunges onward, crushing everything that comes in its path. But just because it is a machine it can and will be destroyed. It will wear itself out, and as it weakens it will find that the power opposing it grows stronger and stronger. Force will be met by greater force; ingenuity by greater ingenuity; endurance by greater endurance. The first battle has been lost, but only the enemy knows at what cost to himself. But in losing it the Allies have gained knowledge which is already being turned to account. They know now German methods and German resources. Means of meeting the peril of the tank have been extemporised, the air menace has been fairly met. The enemy's supply of the fuel which his vast machine demands has been curtailed, his organisation has been broken up, his means of communication disrupted. Everywhere he is weaker than he was, and our strength is growing. We know now the weapons we need and can concentrate on their production. Our Air Force is being continuously recruited, our Navy grows daily in strength, and our battle against mechanised units will soon be waged with new weapons and with tanks as mighty as Germany's mightiest. The Empire is awake! It is an engineer's war against a machine, and the engineer will devise the means of destroying the machine and restoring peace to the world it has frightened.

Aircraft *versus* Ships

AN agreement to differ may be held to be the chief result of the pre-war discussions on the respective strengths, in contest, between aircraft and ships; exercises under peace conditions could not, it was felt, really determine the relative fighting powers and only actual test in warfare could settle the matter.

We have now had experience of many months of war, and it is not unreasonable to inquire whether this question can yet be answered. It is, of course, less a single question than a group covered by a single title, for there are ships and ships. If we consider first the vitally important question of the battleship, it may be said at once that we do know a great deal more than we did. It is true that we knew beforehand that the battleship of to-day was strongly protected by deck armour and was difficult to hit. To penetrate armour requires high striking velocity, and this in turn calls for a high altitude of attack on the part of the aircraft, though the greater this height the less chance of hitting. Hence the two chief attack requisites were, and still are, mutually conflicting. Nor can modern developments, whether under peace or war, materially affect this position. The bombs now in use are better streamlined than in the last war, and they are heavier, but even so the velocity they acquire during descent remains much where it was. Even were air resistance entirely removed, the vertical velocity attained from any height could not exceed that corresponding to a vacuum trajectory, which from 20,000ft. is but 1100ft. per second; in practice it would, of course, be materially less, and even were the height of release pushed up to 30,000ft., or even 40,000ft., the velocity would be but little greater since in the neighbourhood of the speed of sound the rapid rise in air resistance cushions further increase. Nor could an attack during a dive from high altitude materially alter the situation, since an initial downward speed of even 400ft. per second would hardly affect the velocity at sea level. To fire the bomb downward fast enough to increase the ultimate speed would, for a bomb of adequate size, require an aircraft gun of such dimensions and weight as to be outside the field of possibility; whilst any form of rocket-bomb is likely to present great practical difficulties. Hence, if the armoured deck can keep out a bomb which arrives with a striking velocity of 1100ft. per second, it can be said to have the latter beaten. And this, our present war experience has shown it can do. One at least of our battleships has been hit by such a bomb and the armoured deck has proved to be just that protection which our naval architect said it would be. Hence the contest between the battleship and the bomb has largely ceased to be the doubtful factor that it was. It is true that this leaves out of account the "near-miss," the bomb which explodes under water close to the ship, but this should be regarded rather as an attack by a mine or aerial torpedo than by a bomb. The essence of a bomb is to cause such an explosion inside a ship as will damage the vital machinery below the armoured deck, or even hole the ship from the inside; whereas the object of the mine is to blow in the side or bottom of the ship by means of the intense pressure wave created in the water by its detonation. Hence the "near-miss" must be looked upon as a mining attack and any battleship adequately protected against mine and torpedo may be looked on as protected also against the "near-miss."

When one comes, however, to smaller and less important ships the problem takes another form, for as size goes down the difficulty of hitting rises rapidly. The accuracy of bomb sighting must

depend upon the steadiness of the aeroplane's speed and course, but both of these are affected by the atmospheric turbulence always present in one degree or another; it is least just above a cloud bank or in a fog, but those are not conditions that favour bombing attack. This natural limit to bombing accuracy is one which it will always be hard for even the greatest human ingenuity to surmount. If it is evaded by making the attack from a low height in a dive, it can only be at the cost of giving up any idea of high penetrating power, and accepting a considerably enhanced risk of being shot down by the ship's anti-aircraft batteries. This particular type of contest has not yet been worked out to a conclusion, but it certainly looks as if the surface ship is holding her own reasonably well. Possibly, in view of the great number of bombs that are dropped in proportion to the hits obtained, the contest will usually be decided by the numbers of aircraft which a belligerent can spare to operate in any one theatre at one time.

To the general question, therefore, of the relative strengths of aircraft and ships the answer seems to be taking the form that, whilst the battleship is beating the bomb, there is much to be said in favour of the view that aircraft have the better of the fight in the case of the smaller ships, provided that they can attack in great numerical superiority, though even then the anti-aircraft armament carried by the ship may be expected to exact a heavy toll from its attackers.

Vector Analysis and Locomotive Counterbalancing

By LAWFORD H. FRY

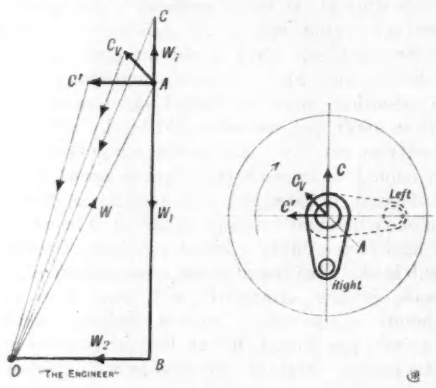
THE application of vector analysis to engine balancing has been dealt with extensively by Dalby in his classic work. The present example shows its use in a consideration of overbalance for reciprocating parts in a locomotive with particular attention to the case where the full counterbalance desired cannot be applied.

Fig. 1 applies to one wheel of a pair of main driving wheels in which the inertia effect of the rotating parts is represented by the vector AB, of equivalent weight W_1, due to the parts adjacent to the wheel, together with the vector BO, of equivalent weight W_2, due to the rotating parts on the other side of the engine.

Then for complete balance of the rotating parts there must be added a vector OA, of equivalent weight $W=\sqrt{W_1^2+W_2^2}$.

If overbalance of equivalent weight W_7 is desired to oppose the fore-and-aft throw of the reciprocating parts on each side, this can be obtained by one of the three methods indicated in Figs. 1 and 2:—

(*a*) By the vector AC, of equivalent weight W_7, acting along the radius of the crank away



FIGS. 1 AND 2

from the pin, see Fig. 2. This opposes the throw of the reciprocating parts attached to the wheel in which the balance is placed. This is known as straight reciprocal balance.

(*b*) By the vector AC', of equivalent weight W_7, acting at right angles to the crank radius. This opposes the throw of the reciprocating parts on the opposite side of the engine. In the right wheel it balances against the *left*-hand reciprocating parts and *vice versa*. This arrangement is known as reverse cross-reciprocating balance.

(*c*) By the vector AC_v. This vector placed at an angle of 135 deg. from each of the two crank radii has an equivalent weight of $0{\cdot}707W_7$. Because of its position this vector develops a component $0{\cdot}707\times0{\cdot}707W_7=W_7/2$ to oppose the parts attached to each crank. Therefore both wheels develop a component, W_7, to oppose each set of reciprocating parts. This is the Vaughan reciprocal balance.

Reverting to Fig. 1, the vector OA represents the unbalance produced by the rotating parts. If counterbalance represented by the vector CO is added to this, the net unbalanced equivalent weight will be that represented by the vector AC, which acts as straight overbalance against the reciprocating parts. Similarly counterbalance represented by the vector C'O will leave AC' unbalanced for reverse cross-reciprocating parts, while C_vO as counterbalance provides the overbalance desired for the Vaughan reciprocating balance.

The amount of counterbalance required for each of the three arrangements is proportional to the vectors OC, OC_v, and OC'. The reverse cross-reciprocating balance arrangement requires the counterbalance of least equivalent weight.

The centrifugal force of the unbalanced vector, as AC, causes the dynamic augment. The vectors AC and AC' are equal, with an equivalent weight W_7, and produce equal augment. The vector AC_v, of the Vaughan arrangement, has an equivalent weight of only $0{\cdot}707W_7$, and therefore produces less dynamic augment in the wheel. When the axle is considered, the maximum dynamic augment develops when the cranks are above the horizontal making angles of 45 deg. with the vertical. The sum of the augments in both wheels is then the centrifugal force of the equivalent weight $1{\cdot}414W_7$ in all three cases.

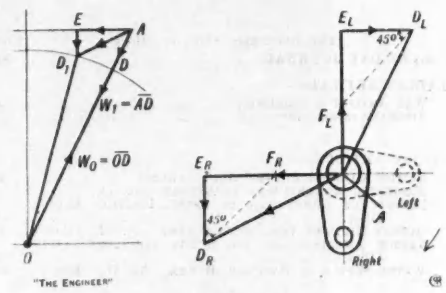
Fig. 3 offers a study of conditions when the main wheel is too small to permit the application of enough balance to take care of the rotating parts. As before, the vector OA, of equivalent weight W, represents the unbalance due to the rotating parts. In the present case it is assumed that the greatest amount of counterbalance that can be applied to the wheel has the equivalent weight W_o, represented by DO. A circle D_1D is drawn with this radius. The radii of this circle represent counterbalance vectors which can be applied. If the balance vector DO be applied acting along the line of the vector rotating parts, AO, the net unbalance will be the vector AD. This position of the insufficient counterbalance, with its vector coincident with the vector of the rotating parts, gives the least possible amount of underbalance and consequently the least possible amount of dynamic augment.

It may, however, be found desirable to give the counterbalance another position, as for example OD_1 which increases the dynamic augment, but allows the underbalance AD_1 to develop a component opposing the fore-and-aft throw of the reciprocating parts. This effect may be seen in Fig. 4, which shows the underbalances for both sides of the engine.

On the right-hand side the underbalance AD_R has a horizontal component AE_R which is opposing the throw of the left-hand reciprocating parts. The vertical component E_RD_R does not affect the horizontal throw. On the left-hand side the horizontal component E_LD_L is acting with the throw of the left-hand parts, thus reducing the balance effect of AE_R. The net balance opposing the throw of the left-hand parts is AF_R, when E_RF_R is equal to E_LD_L. Similarly, on the left-hand side the balance opposing the throw of the right-hand parts is represented by AF_L. Since E_RD_R is equal to E_LD_L the F points are easily found, as in Fig. 4, by drawing D_RF_R at 45 deg. to D_RE_R; and similarly, on the left side.

Inspection of Fig. 4 shows that if the vector AD_R makes an angle of 45 deg. with the vertical, the component AF_R will be zero, and there will be no balance for the fore-and-aft throw. If D_R be moved still nearer the crank radius the component AF_R will be directed along the crank radius and will act to increase the throw of the right-hand reciprocating parts.

The choice of position for the insufficient counterbalance will be governed in each case by the conditions of that particular case. Fig. 5 gives an example drawn to scale. The equivalent



FIGS. 3 AND 4

weights of the components of the rotating parts are:—

W_1 =2400 lb.
W_2 =400 lb.
$W=\sqrt{2400^2+400^2}=2435$ lb.

The equivalent weight of the maximum counterbalance that can be applied is,

$W_o=2200$ lb.

If the counterbalance vector coincides with the vector of the rotating parts the underbalance is AD=235 lb. This produces the dynamic augment, and the net component AF=100 lb. acts to increase the throw of the right-hand reciprocating parts.

If the counterbalance vector is moved over from the position OD to OD_{45} so that AD_{45} makes an angle of 45 deg. with the vertical, the underbalance producing dynamic augment is $AD_{45}=290$ lb., and there is no component affecting fore-and-aft

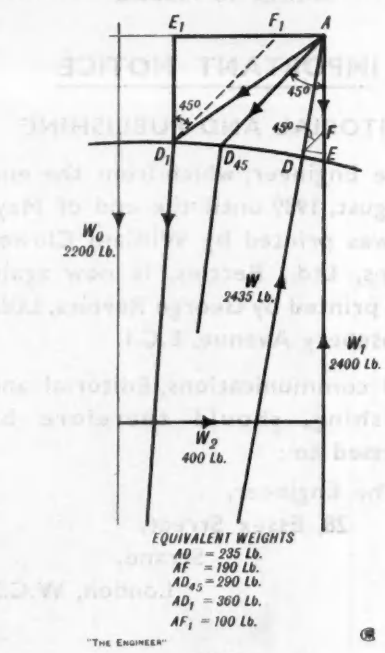


FIG. 5

throw. An increase of 55 lb. in the vector producing dynamic augment has eliminated a vector of 190 lb. equivalent weight producing fore-and-aft force.

If the counterbalance vector be moved still farther to the left, to the position OD_1, the underbalance producing dynamic augment will be $AD_1=360$ lb. and the component $AF_1=100$ lb. will oppose the fore-and-aft throw. By drawing the diagram to a larger scale the values tabulated below are found:—

Underbalance producing dynamic augment. lb.	Balance opposing fore-and-aft force. lb.
235	−190
290	0
340	50
360	100
405	150
445	200

These are the equivalent weights producing dynamic augment and balance for the reciprocating

parts when the counterbalance that can be applied has an equivalent weight 235 lb. less than that required completely to balance the rotating parts.

The driving wheel diameter is small, as otherwise there would be no difficulty in applying sufficient counterbalance. High speeds are therefore not probable, so that extreme refinements in balance will probably not be necessary. It will probably be satisfactory to work with the counterbalance vector near the OD_{45} position so that no large component of the underbalance will act with the reciprocating parts. Beyond this point there does not seem to be much advantage in increasing dynamic augment to reduce fore-and-aft force.

The best solution in any particular case is a matter for special study.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

WAR INVENTIONS

SIR,—As an inventor I am in entire agreement with the opinions expressed in your "Leader" of May 31st. It is about time that the proper use was made of the inventive brains in this country, particularly those of the trained engineer.

In the past encouragement was never given to inventors outside Service Departments for war stores inventions. If one ever did get a hearing it was in a very perfunctory manner; also, one had the feeling of the unuttered remark, "Oh! Poor fellow; he lacks the necessary details." Whereas, if a little indication had been given by those concerned, many so-called unsuccessful inventions might have been a success and of great utility.

The lax treatment of inventors also applies to engineering firms. An outsider is generally given scant treatment, particularly if he has no friends "at court."

Many inventions are of use to the community, but this is not the first point to be considered by the manufacturer. The only ones are—what are we going to make out of it; is it worth the trouble; and even petty jealousies creep in.

It is only fair to say that there are exceptions in manufacturers, particularly if the managing directors are broad-minded, and I think it only fair to use a personal case in this connection. I had invented a certain mechanism, and thereafter wrote to the managing director of a certain firm giving broad details. He being a far-seeing man, sent for me to discuss the matter. We met and at that meeting he said that if I could make it suit his type of business we could do business together, and we have successfully done so to our mutual benefit.

The article referred to is a mass-production piece of mechanism, and in consequence of the managing director's help, together with that of his factory, I was enabled to use a great number of standard parts in my invention, thereby saving considerable toolage. Moreover, this permitted me to design successfully the whole for a perfect mass-production effort.

If all firms would only take the professional engineer inventor into their confidence and not treat him as a rival to their staffs, much more could be done to stimulate inventions from the right men available in this country.

Something must be done to stop the stifling of engineer inventors in this country, and your "Leader" is definitely a great step in the right direction.

THOS. A. BROWN,
A.M. Inst. C.E., A.M.I. Mech. E.

Wembley, June 3rd.

THE WANING OF THE "YES MAN"

SIR,—My attention has been drawn to a recent advertisement in your columns for a situation, in which the candidate terminates his qualifications by adding "Not a Yes Man." The direct inference from this being that at long last employers may be attracted by the services of other than "yes men," indicates such a change of heart that the event should not be allowed to pass relatively unnoticed in that ephemeral part of your journal, the advertisement pages.

The writer, having been many years in engineering industry and Government service, both at home and abroad, here registers his experience that the greatest defect in British organisations, particularly in engineering and Government—where, naturally, his experience has been greatest—but not confined to such, has been the stultifying presence of "yes men."

Amongst really successful administrators little patience is exhibited with the "yes man" the very nature of such individuals constituting a primary shortcoming in that step of an organisation where they occur and thus requiring elimination; whereas failures of administrations are frequently found to be intimately linked with the presence of "yes men." Therefore it is felt that the awakening of engineering and other industry, also last, but not least, in the region of governmental affairs, to the capital disadvantages of "yes men" should be heralded at least by a "Letter to the Editor" from MIDLOCO.

PROPORTIONAL DISC LOSSES IN PUMPS AND FANS

SIR,—Mr. McDonald's letter on the "Bearing Losses of Fans and Pumps" was read with considerable interest, as the writer has also been engaged in analysing the various losses in pumps and fans. The disc friction, although of hydraulic origin, is often regarded as a mechanical loss. The following analysis may therefore be of interest in this connection.

If the power required to rotate a disc against fluid friction be examined dimensionally, the following functional equation may be formed:—

$$\frac{P_d}{\rho\, n^3 d^5} = f\left(\frac{n\,d^2}{\nu}, \frac{k}{d}, \frac{c}{d}\right)$$

where P_d is the power.
ρ the fluid density.
n the rotational speed.
d the disc diameter.
ν the kinematic viscosity.
k the mean height of the roughness projections.
c the clearance between disc and casing.

The units of the quantities within each group should, of course, be consistent with one another. It has been shown that both the roughness and clearance factors do affect the power loss,[1] but as far as the writer knows this has not yet been put in any precise mathematical terms. It may be presumed, however, that the effect of roughness is the same as in channel flow, and this has been thoroughly investigated. The effect of clearance differences will probably be small when the clearance is relatively large unless the fluid is very viscous. For smooth discs with relatively large clearance there is a good deal of experimental work available.[2] It appears that the critical value of the Reynolds' number $n\,d^2/\nu$ for transition from viscous to turbulent condition is about 60,000. This is outside the range of water pumps and fans, but may easily be within the range of pumps dealing with the more viscous fluids. Writing $n\,d^2/\nu = R_e$, the formula for viscous flow becomes

$$P_d/\rho\, n^3 d^5 = 1{\cdot}193\, R_e^{-\frac{1}{2}},$$

whilst for smooth turbulent flow, Karman gives the formula (reduced to the units used in this note),

$$\frac{P_d}{\rho n^3 d^5} = 0{\cdot}517\, R_e^{-\frac{1}{2}}$$

If the disc power loss be divided by the hydraulic power output, a proportional loss may be obtained. The hydraulic power (P) obtained from the pump is $g\,h\,\rho\,q$, therefore the proportional loss for smooth turbulent flow is

$$\frac{P_d}{P} = 0{\cdot}517\, R_e^{-\frac{1}{2}}\, \frac{\rho\, n^3 d^5}{g\,h\,\rho\,q}$$

$$= 0{\cdot}517\, R_e^{-\frac{1}{2}} \left(\frac{n^3 d^2}{g\,h}\right)\left(\frac{n\,d^3}{q}\right)$$

There is evidence to show that[3] for a given value of $q/n\,d^3$, $g\,h/n^2 d^2$ is almost independent of R_e for a considerable range of R_e. It follows then that under synchronous flow conditions ($q/n\,d^3$=constant) the disc friction of a set of geometrically similar pumps is inversely proportional to the fifth root of the Reynolds' number. Since disc friction affects the efficiency but not the head, this provides one reason why change of viscosity affects the efficiency more than it affects the head developed.[4]

In pump literature a non-dimensional factor $\phi = u/\sqrt{2\,g\,h}$ is often used, where u is the peripheral speed of the impeller.

The use of this factor and the specific speed $n_s = \dfrac{n\,q^{\frac{1}{2}}}{(g\,h)^{\frac{3}{4}}}$ [5] in its non-dimensional form gives

$$\frac{P_d}{P} = 0{\cdot}00955\, R_e^{-\frac{1}{2}}\, \frac{\phi^5}{n_s^3}$$

Considering one or two cases:—

(1) Low specific speed $n_s = 0{\cdot}07$ (N_s in British gallons per min. units = 1100), disc 8in. diameter, speed 3000 r.p.m., $\phi = 0{\cdot}90$, $\nu = 0{\cdot}01$ c.g.s. unit.

$$R_e = \frac{50 \times (8 \times 2{\cdot}54)^2}{0{\cdot}01} = 2{\cdot}06 \times 10^6.$$

Proportional disc loss = 0·0628.

(2) Medium specific speed $n_s = 0{\cdot}14$ (N_s = 2200), disc 16in. diameter, speed 1500 r.p.m., $\phi = 1{\cdot}05$, $\nu = 0{\cdot}01$ c.g.s. unit.

$$R_e = 4{\cdot}12 \times 10^6.$$

Proportional disc loss = 0·0296.

(3) High specific speed $n_s = 0{\cdot}28$ (N_s = 4400), disc 32in. diameter, speed 750 r.p.m., $\phi = 1{\cdot}25$, $\nu = 0{\cdot}01$ c.g.s. unit,

$$R_e = 8{\cdot}24 \times 10^6.$$

Proportional disc loss = 0·0154.

J. JENNINGS,
B.Sc., A.M.I. Mech. E.

Aston Technical College, Birmingham.

[1] "Hydraulics," A. H. Gibson, page 190.

[2] See Modern Developments in Fluid Mechanics (Composed by the Fluid Motion Panel of the Aeronautical Research Committee), Vol. II, pages 367–8.

[3] THE ENGINEER, May 19th, 1939, and June 23rd, 1939, "Dimensional Analysis of Centrifugal Pump Characteristics," G. G. McDonald, pages 619 and 773.

[4] For a further reason see the above letters.

[5] For derivation see THE ENGINEER, May 19th, 1939, page 614.

Sixty Years Ago

"A WARNING TO ENGINE DRIVERS"

FOR thirty-three years William M'Culloch had been in the service of the Caledonian Railway and for twenty-five years had been driving passenger trains. He had never had an accident and bore an exemplary character until January 24th, 1880. On that day he was in charge of a down express from Carlisle which overran the signals at Rutherglen and crashed into the tail of a passenger train from Carstairs to Glasgow. The Board of Trade inspector attributed the accident to carelessness on M'Culloch's part in that he failed to take steps to check the speed of his train until he was within 300 yards of the distant signal which was at danger and past which he ran at a speed—about 35 miles an hour—which was too high to permit him to bring the train to a full stop before reaching the home signal—also at danger—some 600 yards further on. M'Culloch was placed on trial before Sheriff Lees of Glasgow, who sentenced him to four months' imprisonment. The case excited much interest because it was widely felt that M'Culloch had been punished for placing unjustified faith in the Clark and Webb emergency chain brake with which his train was fitted. The complete braking equipment of the train consisted of a hand brake operating blocks on the tender wheels, a hand brake in each of two 9-ton brake vans, and the Clark and Webb chain brake. The chain brake was in two sections, one controlled either by the engine driver or from the front brake van, and the other from the rear brake van. On sighting the distant signal, 300 yards away, M'Culloch applied all the brake power at his command and, finding that his speed was still high when halfway between the distant and home signals, whistled to the rear guard as a signal to apply the second portion of the chain brake. It was, however, by then too late, and at a speed of about 15 miles an hour the Carlisle train ran into the tail of the Carstairs train. It was urged on M'Culloch's behalf that the front section of the chain brake had completely failed to act. That statement was accepted as true both by the Board of Trade inspector and by the Sheriff. M'Culloch was punished because in the Sheriff's own words, he "rashly and culpably trusted to certain possibilities"—namely the efficient action of the chain brake—"as a means of avoiding a danger that was otherwise inevitable." After M'Culloch had been sentenced we expressed the view in a leading article in our issue of May 21st, 1880, that his case should be taken as a warning by all engine drivers as to what they might expect if they placed any confidence in emergency brakes. Others went farther and asserted that M'Culloch had been punished in order to save the reputation of the Clark and Webb brake. One of our readers was so incensed at the injustice of the punishment that he took the subject up with the Home Secretary. Partial success attended his efforts, and M'Culloch's sentence was reduced to two months' imprisonment. Still many people were dissatisfied, and before M'Culloch was released a subscription fund was opened for him.

WORKERS FOR URGENT WAR WORK.—The Ministry of Labour and National Service announces that a few days ago an appeal was issued to garage mechanics, &c., to volunteer for work in aircraft factories, and the response to that appeal has been magnificent. While the demands for skilled workers for the production of aircraft and munitions of all kinds will grow from day to day, it is inadvisable that transfers of such workers from other industries or services should take place in a manner which might be prejudicial to the conduct of those industries or services which are of vital importance to the maintenance of the civil population and the general conduct of the war. The Minister of Labour and National Service accordingly desires that in future any worker, and in particular any skilled worker, who wishes to volunteer for urgent war work should notify his nearest employment exchange of the fact and should continue with the work that he is doing until he receives further instructions from the employment exchange.

British Canning Plant

No. I

ONE of the most remarkable advances made by British industry in the past decade has been in connection with the canning of fruit, vegetables, milk, fish, &c., and now that war has come this comparatively new industry is playing an important part in the conservation of the nation's food supplies. Although prior to the Great War of 1914–18 there were several canning factories in this country, it was in the subsequent post-war years that the industry really began to grow, and at the moment there are over one hundred modern canneries at work, packing annually many millions of cans of the most varied produce. The yearly consumption of canned products here has been calculated as ten pounds per head of the population, of which figure only about one half emanates from British canneries, so that there is still plenty of scope for further expansion of British canning activities, although a certain proportion of canned goods the raw produce for which cannot be grown here must be imported into this country.

Generally speaking, the process of canning such produce as vegetables and fruit is conducted in well-defined stages which may be set out as follows:—(1) Removal of unwanted material from the produce, grading, washing, and blanching; (2) filling into cans and adding brine or syrup; (3) exhausting the air from the filled cans; ((4) sealing the cans; (5) sterilising by heat and cooling.

Canning Peas

The machinery and plant employed to handle different kinds of produce varies considerably in the initial stages of the processes, but has a marked similarity from the point when the produce is ready for actual canning. Peas may be taken as a typical example. For the preliminary handling of these a machine known as a "viner" will deal with the whole of the pea plant as pulled up from the fields and extract the peas from the pods in one operation, one viner being capable of treating peas from an area up to 90 acres in one season. The principles of the construction of a machine of this type is outlined in Fig. 1, which is partly self-explanatory. Pea plants are fed to the conveyor which carries them at a predetermined rate into the revolving drum, wherein they meet specially designed beater blades mounted on an inner drum. The action of the blades is sufficient to split open the pods but not enough to damage the peas. When released, the latter pass through the outer riddle drum, while the vines are carried forward to the far end of the drum, leaving the machine by means of a conveyor at a convenient height for direct loading on to vehicles. The viner has riveted steel frames to ensure rigidity and smooth operation on heavy loads, and the positive drive of the riddle drum avoids slipping when operating on wet vines. As a safeguard against choking owing to uneven feeding the feed conveyor is provided with a series of safety pins. The apron cloth is made in one piece, and is fitted with roller-mounted steel stiffeners operating in steel side frames forming a continuous guide. The main rolls have adjustable bearings to provide for uniform cloth tension. Self-aligning ball bearings are fitted on all shafts of the main beater drive and riddle drum, and the beater drum and main apron conveyor drives are operated by silent roller chains. The speed of the beater drums can be varied to suit the condition of the peas by a set of change-speed gears in a few minutes. The conveyor carrying the spent vines is friction-driven to ensure smooth running and to avoid damage when handling heavy loads, and all bearings are fitted for grease gun lubrication.

It will be recognised that a machine such as the viner when installed near the pea-growing plots saves the heavy transport costs of conveying even the pods to the cannery, besides which it enables the spent vines and empty pods to be left in the area where they are most wanted, as animal food and manure. However, in some cases, according to local conditions, the pods are picked from the growing plants, which are afterwards ploughed in, the podded peas being sent to the cannery. In this case a pea-podding machine is employed to remove the peas from the pods. A typical example of such a machine will handle three hundred 40 lb. bags of podded peas per hour. The principle of operation is similar in some respects to that of the viner but a bucket feed elevator is synchronised with the feed worm to reduce labour and ensure correct feeding. Construction is of fabricated steel channels, the beater drum being fabricated steel with hickory beater blades, and carried on ball bearings. The apron conveyor in the machine is of aluminium and fitted with a mechanical brush system for wiping away the waste. Leaving these machines, the peas are next given a thorough wash by strong jets of water playing on them as they advance slowly in a single layer. Grading of the peas into different sizes is the next step, and is conveniently done in revolving drums having suitable apertures on their surface. There are several reasons for the grading of peas before canning. It affects the question of the proportion of produce to brine going into the can, the appearance of the canned goods, and the length of the period of cooking or sterilising required. After grading, the peas are put through a blancher, generally a cylindrical tank containing weak brine or similar solution heated by a steam coil or jacket. This process, besides removing the glutinous matter from the surface of the peas, causes a separation of sound peas from any bad ones present. Since the latter have a specific gravity differing from the former separation takes place in the brine. The temperature and period of processing in the blancher are carefully regulated to suit the characteristics of the produce. After a further washing and inspection the peas are ready to be filled into the cans. For this purpose they are passed into an overhead hopper, from which the filling machine is fed.

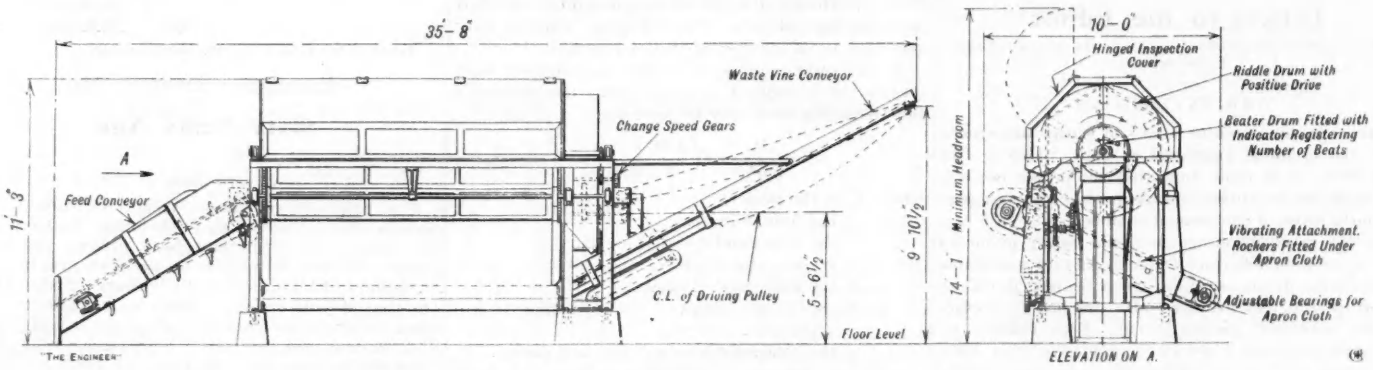


FIG. 1—ARRANGEMENT OF VINER

A modern type of filling machine is outlined in Fig. 2, and is capable of handling a wide variety of produce, including liquid, semi-liquid, or pasty substances, the average output being about 120 cans per minute, but higher speeds are obtainable with some products. The filling machine, which is rotary in operation, receives and discharges the containers in single line. A can stops exactly under a filling nozzle leading from the measuring

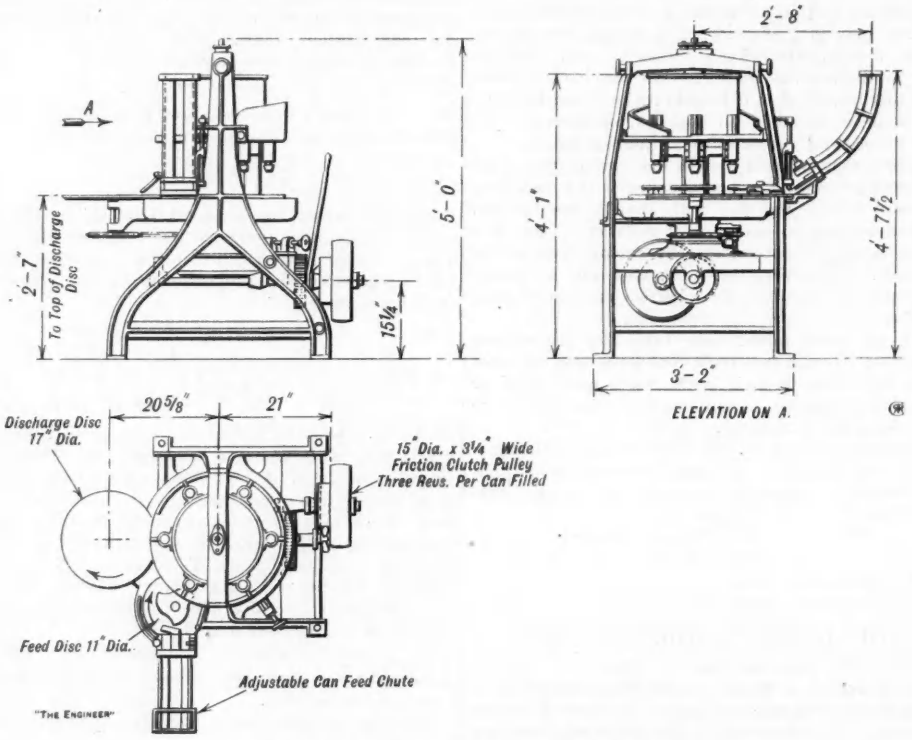


FIG. 2—GENERAL ARRANGEMENT OF FILLING MACHINE

chamber. The nozzles rotate under a stationary cut-off plate and are thus opened and closed in succession. When the measuring chamber is filled and closed from above a piston mounted in each chamber and actuated by passing over a cam plate below rises and pushes the produce through a side discharge opening leading from the chamber to the discharge nozzle. A supplementary small reciprocating plunger working in the nozzle serves as a final cut-off and clears the nozzle of material intended for the container, which is filled without any waste. The parts of

the filler coming into contact with the produce are of bronze with a Monel metal feed hopper, the latter being provided with a bronze screw plate to assist the flow to the filling pockets. A useful feature of the machine is the no-can no-fill device. If there is no can under the nozzle the produce is returned automatically to the hopper. For different sizes of cans the parts of the machine handling the cans can be quickly changed.

From the filling machine the filled cans pass directly into an exhauster, the object of which is to expel air and other gases from the can before sealing up. Such gases if allowed to remain would cause deterioration of the produce and possibly bulging of the cans at a later stage. In this machine the cans are caused to pursue a circuitous route through either a hot water or a steam bath, the temperature and time of contact with the heat depending mainly on the size of can and the nature of its contents. Can tracks are arranged in a single tier in this particular machine, which facilitates inspection when necessary. The exhauster is built up on a fabricated steel framework and has a substantial platform on which the driving mechanism is fitted. It is so designed that the working mechanism can be lifted from the tank for inspection without dismantling. The machine is fitted with a continuous malleable iron steel-pin type chain so supported in angle iron tracks as to maintain the cans in the correct position during their journey through the vessel, and so driven that the load is evenly distributed. An overload slipping device is fitted on the main driving mechanism, so that in the event of a jam inside or at the points where the cans

FIG. 3—EXHAUSTER

enter or leave the chamber the load is immediately released. Although this slipping device is set originally with a good margin of safety it is adjustable for varying loads. The driving mechanism, consisting of oil-immersed worm-reduction and machine cut gears, is mounted on the outside of the chamber. Fig. 3 is from a close-up photograph showing the can guides, the feed or discharge disc, the overhead drive, oil-immersed worm reduction gearing and texrope drive to a standard motor with push button control. A special feature is the close fitting of the disc to the side of the chamber and the small aperture for the cans to enter or leave the machine, which reduces steam losses to a minimum. This type of exhauster will handle up to 120 cans per minute, depending on the size of the machine, exhausting period, and size of can.

It is of great importance in canning to close the cans from atmosphere as quickly as possible after leaving the exhauster and while they are still hot, and in practice the time elapsing between leaving the exhauster and being sealed up is only a few seconds. This quickness of operation ensures that there is no reabsorption of air by the produce and that the headspace in the can above the produce is occupied by water vapour and not by air at the time of sealing; thus a partial vacuum is created within the sealed can on cooling down. The seaming, or sealing machine, which closes the cans after exhausting, is a fairly well-known type of apparatus, being used in many other kinds of industry apart from that which we recognise as canning, and as such it needs no general description. It will be obvious, however, that efficiency in the seaming machine is just as necessary as it is in any other unit in the canning line, for a can of produce imperfectly sealed from the atmosphere will quickly render void all the care and attention given to it in the other stages of the process. In some canneries the lids are clinched loosely on to the filled cans before exhausting, the chief advantages being that the lid prevents the steam in the exhauster damaging the surface of delicate produce, and the lid itself is heated up, thus saving reduction in temperature from sealing with cold lids. In other cases the lids are placed in position by an attachment on the seaming machine itself.

The actual closing of the can is done in two operations by means of accurately grooved rolls, the positions of the seams on can and lid in the two operations being seen in Fig. 4. In the first operation the edge of the lid is bent downwards and then hooked under the can edge, in the second operation the hooked edges are pressed firmly together. There are both single-head and double-head seaming machines in general use. On a single-head machine both the first and second operations are done on the same chuck, but on a double-head machine the two seaming operations are done on

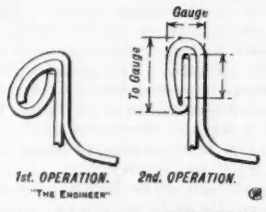


FIG. 4—SEAMING OPERATIONS

separate chucks. An air-tight joint in seaming is often secured by the use of a suitable jointing material such as rubber latex previously placed on the edge of the lid. Like most other automatic machinery the seaming machine requires a certain amount of intelligence on the part of its operator if it is to continue to function efficiently. For example, the actual seaming units, such as the seaming rolls and their bearings, pins, and base-plate must be maintained in good condition. A seaming chuck is made to very accurate dimensions to ensure a correct fit in the countersink of the end, and when an end is pushed fully home on to it it should not be possible to turn the end by hand, otherwise the fit is imperfect. The face of the chuck also needs frequent inspection, because when the edge of the face becomes worn or chipped there is a danger of producing "cut-overs," or sharp edges on the top inside corners of the double seams, usually found where the side seam of the can body joins the lid. These cut-overs cause the can to hang on the chuck during

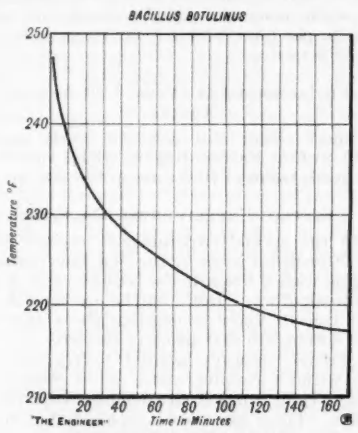


FIG. 5—STERILISATION CURVE

seaming, often resulting in the tin-plate being cut through, so causing a leak. The face of the chuck should be perfectly flat. If it becomes worn the defect is probably caused by the seaming rolls being set too tightly. Incidentally, the seaming rolls should be watched very carefully for signs of binding when in operation, for if the accurate contour of their grooves becomes worn the tin surface will be removed from the can and rust will ensue. The grease used to lubricate the roller bearings should be impervious to brine or syrup, sometimes spilled from the cans, and also to high temperatures. If the roller bearings are neglected the rollers do not revolve properly, so causing wear on the bore of the seaming roll and its groove, and sometimes on the seaming roll itself. A point where the seaming roll pins are liable to wear is where the roller bearing rides. Instances of cans slipping on the chuck during seaming are often due to the serrated surface of the baseplate, on which the can rests, having become worn.

From the seaming machine the sealed cans proceed directly into a cooking or sterilising plant. Probably the greatest advance made during the past few years in connection with canning processes is in the direction of sterilising the canned products. This operation consists essentially of heating the sealed cans to a temperature high enough to destroy all bacteria and fungi which if allowed to live would gradually impair the quality of the produce. The use of chemicals with which to sterilise the produce is forbidden, so that reliance has to be placed entirely on heat. Many forms of bacteria are found in produce for canning, of which only one. *Bacillus Botulinus*, may be said to be resistant to heat of ordinary cooking temperatures, so that temperatures used in sterilising are based on the temperature at which this form of bacteria is destroyed. A glance at the diagram Fig. 5, based on the work of Esty and Meyer, will show that even this micro-organism can be destroyed at relatively low temperatures if the heating period is long enough, but in practical canning it is more economical to increase the temperature and so shorten the period of sterilising and increase the output. The heat used in sterilising serves also to cook the produce, although the primary reason for heating to a high temperature is to sterilise. In general canned fruits are more easily sterilised, owing to the acidity present, than are vegetables. Some fruits may be sterilised at temperatures between 200 to 220 deg. Fah., but the micro-organisms in certain vegetables are of a more hardy nature and require a temperature of about 250 deg. Fah. to effect their destruction. In practice, however, a margin of safety is desirable and most produce is sterilised at about 260 deg. Fah.

It will be obvious that in designing a vessel to sterilise thousands of cans of produce an hour much thought must be given to the many and varied types of produce now canned, in their different sizes of cans, and with varying rates of heat-penetration. W. D. Bigelow, of the National Canners' Association, Washington, has investigated the rate of heat penetration to the centre of filled cans, using a thermocouple which could be applied to both stationary and agitating types of sterilisers. Bigelow comes to the conclusion that the time necessary for heat to penetrate to the centre of cylindrical cans of various sizes, carrying identical produce, is approximately proportional to the squares of the radii when the length of cans exceeds their diameter. Although it is desirable that cans of produce entering a steriliser should be hot in all cases, small variations in the temperatures of the cans do not appreciably affect the length of time required in the steriliser with certain classes of produce, for it is found that if two cans of similar size, not at the same temperature, enter the steriliser together the can with the lower temperature will heat more quickly than the other, and the centres of the two cans attain the temperature of the steriliser at practically indentical times. With such produce as canned peas, consisting of a clear liquid with small solid masses floating freely in it, heat-penetration, by means of convection currents, is fairly rapid, and in this case an agitating steriliser will serve to accelerate the penetration of heat to the centre of the can. With delicate produce, however, an agitating steriliser cannot generally be used for fear of damaging the goods. With larger masses, like tomatoes, or plums, which interfere with convection currents, movement of the cans during sterilisation is practically essential for quick heat-penetration.

(To be continued.)

THE LATE MR. J. F. I. THOMAS.—We regret to learn that Mr. J. F. I. Thomas, vice-chairman and managing director of British Jeffrey-Diamond, Ltd., Stennard Works, Wakefield, died at Bournemouth on May 25th. During the last war Mr. Thomas carried out important work for the British Government in America, and was later awarded the O.B.E. For a time he was connected with Vickers, Ltd., and had travelled abroad extensively on various business activities. He was widely known in the Sheffield steel industry. In 1931 he joined the board of British Jeffrey-Diamond, Ltd., as managing director, and was later appointed vice-chairman.

ASSISTANCE WITH TECHNICAL PROBLEMS.—The International Tin Research and Development Council, Fraser Road, Greenford, Middlesex, announces that it has accumulated much experience, particularly since the war began, on a wide range of processes in which tin is directly or indirectly concerned, and that this experience is available to any who needs it—without charge. These processes include grease-tinning and hot-tinning, soldering, bearings and bearing materials, bronze, electro-tinning, and fusible alloys, particularly for rapid die and punch mounting, tube bending, &c. Advice can sometimes be given by correspondence, but as in many cases personal contact is much more effective, the Council is prepared to send members of its staff to give assistance and advice at a firm's works.

Recent Developments in Steam Locomotive Design in France*

By MONSIEUR CHAN.†

Two factors have always governed the development of the steam locomotive in France. First of all, they have had to build economical engines with a low fuel consumption, owing to the fact that coal has to a large extent to be imported. In the second place, they must have powerful engines because of the weight of the trains. Since 1922 we have put into service steel coaches, very few of which weigh less than 50 tons, and out of a total of 8988 bogie coaches, 3155 are of all-steel construction. The weight of the passenger trains is usually about 640 tons and sometimes reaches 740 tons. While it is true that since 1937 the French railways have succeeded in reducing the weight of their coaches—the latest design, 72ft. long and completely fitted with up-to-date equipment, will not weigh more than 39 tons—the need for powerful locomotives must remain a constant preoccupation for a long time. This problem of power must, moreover, be solved in spite of a very strict limitation of weight, as they cannot on most French lines exceed 18·5 tons per axle. On only a few main lines is 20 tons per axle permissible.

The 4–8–0 Locomotive of the Paris–Orleans Railway

Although this engine, designed by Monsieur Chapelon, dates as far back as 1935, it is not without interest, as it embodies most of the modern improvements in locomotive practice. As a matter of fact, the French railways are at present building twenty-five new engines of this type, which will be delivered this year and are intended for the haulage of heavy express passenger trains on the main line between Paris and Lyons, where long gradients of 1 in 125 are encountered. These engines will be fitted with a mechanical stoker.

Their principal particulars are as follows :—

Wheel diameter	6ft. 1in.
High-pressure cylinders :	
Diameter	17½in.
Stroke	25½in.
Low-pressure cylinders :	
Diameter	25½in.
Stroke	25½in.
Working pressure	285 lb. per sq. in.
Grate area	40·45 sq. ft.
Exhaust	Kylchap double chimney
Superheater	Houlet type, giving 750–800 deg. Fah.
Speed	75 m.p.h. (can be raised to 87 m.p.h.)
Tractive effort	3000 H.P. on the drawbar at 62 m.p.h.
Coal consumption	2·20 lb. per hour per H.P. on the drawbar at 62 m.p.h.

The weight is 107 tons plus 79 tons for the tender, which has a capacity of about 10,000 gallons.

(In France there are only three water-feeding troughs, all on the Western Region.)

This locomotive is particularly remarkable for its small grate area (40·45 square feet) and reduced weight in spite of the very high horse-power available in the cylinders, about 4000 H.P. This engine seems to have retained the record for the lowest weight per horse-power, 60·6 lb. per horse-power, a ratio which, so far as the author knows, has not been attained in any other steam locomotive.

These results have been obtained by means of the following improvements :—

First, the blast pipe, which is a Kylchap of the double 1 K/1 C type, designed as long ago as 1933.

Owing to the separate passages specially designed for steam and smoke, the Kylchap exhaust secures a given vacuum with a considerably reduced back pressure ; the back pressure, as compared with that of the older *trèfle* exhaust, is reduced to one-half for the low consumption rates and to one-third for the higher ones. As much as 250 H.P. is gained at full power.

There are some other types of exhausts to be found on French locomotives with the necessary widths of steam ports, which give approximately the same good results.

All these improved types of exhausts with wide steam ports have allowed of an increase in the rates of combustion in the boilers to an extent which could hardly be obtained before. It has been possible to burn more than 2200 lb. per 10·76 square feet on the grate of 40·45 square feet area fitted to the above-mentioned engines, and about 1980 lb. per 10·76 square feet on the 46·26 square feet grates of the "Pacific" engines and to obtain easily from existing boilers a steam output of 44,000 lb. per hour.

The evaporation rate attained has reached 220 lb. per 10·76 square feet of superheating surface. In practice at maximum output it is 165 lb. per 10·76 square feet. This figure, although high, presents no disadvantage with the welded steel fire-boxes with welded flues which are now the rule on the French railways. In this connection, and without wishing here to enter into the often disputed question of the respective advantages of copper and steel fire-boxes, the author will simply point out that steel fire-boxes seem beyond all possible doubt to be indispensable for boilers working at high pressure—that is to say, at or over 285 lb. per square inch.

The general use of steel fire-boxes was decided upon in France before the outbreak of the present war. Existing circumstances have rendered this decision most opportune.

The next improvement to be referred to is that realised in superheating. The engine in question is fitted with a Houlet type superheater, which gives the 750 deg. Fah. considered necessary. This new superheater is of annular section. Compared with the Schmidt type, it has this advantage, that it delivers superheated steam as soon as the regulator is opened. Its design has now been perfected, thanks to the use of a special heat-resisting steel which includes 6 per cent. chrome and 0·25 to 0·60 per cent. molybdenum, so that the loops of the superheater can be placed at only 12in. from the tube plate.

Attention must also be drawn to the great improvement effected in the steam ports. Their section was previously one-tenth of the cylinder section. It is now twice as large and equivalent to one-fifth of that of the cylinder. The capacity of the steam chests has been increased to that of the cylinders in order to avoid oscillations in pressure. In addition, large diameter poppet valves were used.

As a result it was possible to raise the pressure in the intermediate receiver from about 30 lb. to 85 lb. per square inch, while the low-pressure cylinders produced approximately the same output as the high-pressure cylinders. The usual objection made to the compound engine of having unproductive and therefore useless low-pressure cylinders was thus removed.

The use of poppet valves is one of the improvements of which particular advantage has been taken in France, either for equipping all the cylinders of an engine, or only the low-pressure cylinders where the use of large steam ports entails difficulty. For that reason there is now in France a total of 335 locomotives equipped with poppet valves. But poppet valves do not represent the only progress made in order to improve the steam ports. Piston valves with double inlet and outlet are also used, the maintenance of which does not entail the employment of such skilled fitters as poppet valves.

It would perhaps be as well at this point to summarise the results of all these different improvements. When applied, for instance, to the "Pacific" locomotives, of which there are altogether 1500, the practical results are as follows :—Whereas an engine designed before 1930 developed at 75 m.p.h. a tractive effort at the drawbar of barely 1300 H.P. with a coal consumption of 3·3 lb. per horse-power hour, the improved "Pacifics" now develop, under the same conditions, a tractive effort of 2400 H.P.—that is to say, an increase of over 80 per cent. in power, with, moreover, a coal consumption reduced to 2·42 lb. per horse-power hour, or an economy of nearly 30 per cent.

Santa Fe Locomotives (Type 2–10–2) for Goods Trains

The most recent and powerful goods engine is the 2–10–2 of the Eastern Region, which was designed to haul goods trains of 1600 tons up 1 in 100 gradients.

Special Experimental Engines

Of all the special experimental engines ordered by the French railways in the last few years, only the engine with a Velox boiler could be tested before the outbreak of war. But it will be, perhaps, interesting for you to know something about the others and the author will first speak of the latter.

The French railways wanted to try out steam engines without coupling-rods, as on electric locomotives. They ordered two engines very different in design. These are now completed, but not yet tested. They are as follows :—

(*a*) *Turbo-locomotive* 4–6–4, *Class "Q," Built by Schneider.*—This engine has 5ft. wheels. The boiler is of the ordinary type with coal feeding, special steel fire-box, and 355 lb. per square inch working pressure. The engine is provided with three turbines, one on each driving axle. Each turbine has forward and reverse sets of blades on the same shaft and is connected with the axle concerned by double reduction gear. The turbines, which are very small, work at 10,000 r.p.m., with the axles turning at 200 r.p.m., and develop 1000 H.P. each.

The coupling to the wheels is of the ordinary Westinghouse type, as used in electric locomotives. No steam-condensing device is provided, and the blast pipe is of the normal type.

This engine is expected to have a very regular torque and to be very economical as far as maintenance costs are concerned, due to the lack of reciprocating parts.

(*b*) *Locomotive* 4–6–4, *Class "P," with Separate Engines to Each Driving Axle and* 850 *lb. per Square Inch Boiler Pressure.*—This engine has 5ft. 1in. wheels. It is provided with a coal-burning, water-tube boiler working at a pressure of 850 lb. per square inch. The feed water first enters a kind of preheater, with a working pressure of 285 lb. per square inch, which is intended to soften the water and supply the steam to the auxiliary engines.

Each axle is driven by two small single-expansion engines, one on each side of the locomotive. There are three driving axles, and therefore six engines altogether. Each engine has three cylinders, 6in. diameter by 10in. stroke, developing 500 H.P. at 1000 r.p.m.—that is to say, 3000 H.P. for the entire locomotive.

Here, again, there is no condensing device, and the blast pipe is of the usual type.

It is also expected to have a very regular torque and to produce a saving in maintenance costs, owing to the fact that all moving parts work in oil.

Despite these experimental types, the French railways do not believe that the standard locomotive has reached its limit of perfection. Monsieur Chapelon has designed a new goods engine of the 2–12–0 type which was completed at the beginning of this year.

It was designed with the object of reducing coal consumption still further. It is, of course, a compound engine, but with two high-pressure and four low-pressure cylinders. There are two superheaters, one in front of the high-pressure cylinders and another one between the high-pressure and the low-pressure cylinders. In addition to this, the cylinders are steam jacketed. The steam passes through the jacket and preheats the cylinders before entering them.

4–6–0 Locomotive with Velox Boiler

The locomotive which was fitted with a Velox boiler by the Compagnie Electro-Mécanique at its Le Bourget works is an old 4–6–0 passenger engine, the ordinary boiler of which was removed and replaced by the Velox boiler. The latter is very efficient, very quick in action, and capable of continuous service. The working pressure was fixed at 285 lb. per square inch owing to the fact that the existing cylinders of the former locomotive were retained.

The principle of the boiler is as follows :—The fuel, which is fuel oil, is burnt in a closed chamber and under a relatively high pressure (3·3 lb. per square inch) instead of at little above atmospheric pressure, as in the normal boiler. Thanks to this high pressure, the hot gases have a very high velocity (about 600ft. per second), and the heat flow is much more active.

The mixture of steam and water passes into a separator, and from there the steam returns to the fire-box and enters the superheater.

The combustion gases pass through a gas turbine to a water preheater. The gas turbine drives a compressor which blows fresh air into the fire-box for combustion purposes. This gas turbine is notable because its blades have to resist a temperature of more than 1000 deg. Fah.

The Velox boiler has a very small water capacity. In this engine, which produces 12 tons of steam per hour, there are only 132 gallons of water to heat when lighting up the boiler, as compared with ten times more in the normal type of boiler for the same output. This is why the Velox boiler is very quick in action. As the working pressure can be obtained in fifteen minutes from cold, the fire may be extinguished and lit again as desired.

Forced circulation is employed and an evaporation rate of nearly 100 lb. per square foot of heating surface, or more than twice that possible with the fire-box of a normal engine, is obtained. Therefore, the boiler itself is of very small dimensions, but, as will be realised, a large amount of space is taken up by the auxiliary engines. There is little vacant space under the streamlining.

In spite of the complication of the auxiliary engines the driver and fireman can be rapidly trained to work the engine. The first operation is to set in motion a small diesel engine which supplies the D.C. required for working the feed pump, the fuel pump, and the air compressor. It is then possible to light the burner by means of an electric resistance. The pressure in the boiler rises, and after ten minutes there is 70 lb. at the pressure gauge. Steam is supplied to the auxiliary engines in the same way as when the locomotive is running and the electric motors are stopped. The pressure continues to rise, and after fifteen minutes the working pressure of 285 lb. per square inch is reached.

Quite satisfactory results were obtained with this locomotive during trials in 1939. It was proved that the starting of the engine was always easily obtainable within fifteen minutes. When in regular service, the Velox locomotive hauled 500-ton trains between Paris and Laroche, and sometimes between Paris and Dijon, the average consumption of fuel oil being 1·95 gallons per kilometre.

It is known that the principal trouble with water-tube boilers is the formation of scale. In the Velox boiler ordinary feed water is used. The particularly rapid circulation of the water counteracts the formation of scale, but in addition a certain part of the feed water is softened by the use of tri-sodium phosphate, and separators and blow-down cocks are fitted. In fact, no trouble at all was experienced.

The efficiency of the boiler is excellent and remains at 85 per cent. The working of the boiler is actually automatic. If the main throttle is suddenly closed, for instance, when the boiler is working at its

* From a paper read before the Institution of Locomotive Engineers on April 17th, 1940, in London.

† Chef de la Division des Etudes de Locomotives à Vapeur, Société Nationale des Chemins de Fer Français.

maximum output, the working pressure increases, but never exceeds 350 lb. per square inch.

With this boiler there is no blast pipe, and therefore there is no need for back pressure. The cylinders of this engine can release the exhaust steam at about 2 lb. per square inch instead of 30 lb. per square inch, as with an ordinary locomotive. At 75 m.p.h. this results in a gain of about 170 H.P. over and above that obtained by the higher efficiency of the boiler.

It was calculated that, whereas an ordinary locomotive burns 2·205 lb. of coal or 2·36 lb. of heavy fuel oil, the locomotive 4–6–0 of the "E" class with Velox boiler burns only 1·256 lb. of 0·91 density fuel oil.

At the import prices of the various fuels obtaining in France during August last, the costs are as follows :—

	Francs.
Ordinary locomotive boiler burning coal—1 ton of coal	215
Ordinary locomotive boiler burning heavy fuel oil —0·62 tons of fuel oil...	185
Velox boiler burning fuel oil—0·57 tons of gas oil	186

With regard to fuel costs, the Velox boiler gives exactly the same results as the normal locomotive boiler burning fuel oil. But the Velox boiler has its own peculiar qualities—very rapid raising of steam and automatic working. Moreover, it can deliver high-pressure steam up to 850 lb. per square inch if necessary, and, up to now, there have been very few, if any, high-pressure boilers which function satisfactorily when used on a locomotive.

Up to the outbreak of war the Velox locomotive had run 12,000 miles without failure.

What the General Manager Thinks About*

By ROBERT THURSTON KENT†

WHAT does the general manager think about? First, last, and all the time, profits. Everything else stems from that. He thinks about a lot of other things, such as budgets, sales policies, shop methods, public relations, labour relations, the Wagner Act, the Wage and Hour Law, how he can get more help, costs, collections, credits and, in an engineering concern, engineering problems in all their phases. He also thinks about market analyses, not only for new products that he is considering, but also for products that are already being made. He thinks about what his competitors are doing. He tries to forecast what improvements in product they will be making in the next year, or five years, and he thinks about how he can beat them to it. But if there are no profits, he will not very long have to think about any of these things, for with lack of profits his company will, within a longer or shorter time, fold up and die. The general manager then will join the great army of the unemployed, and what he thinks about most then will be how to find a new job for himself.

PROFITS—THE PRIME CONSIDERATION

A few weeks ago I was talking with a group of men and indicated to them that I had been invited to come up to Cornell and address you young men. I stated to these men that I could sum up this entire address in one word—profits. These gentlemen were horror-stricken at the idea of my boldly coming out and saying that profits were the prime consideration of management. In these days of unrest and baiting of business they thought it would be highly dangerous to mention anything so sordid as profits, especially to a group of young men just starting out in life. I have no apologies to make for making profits the central theme of what I intend to talk about to-day. So long as this country operates under the economic system under which it has grown to greatness in the last one hundred and fifty years, namely, private industry and free competition, the profit motive is absolutely necessary to its existence. The only alternative to profits is, in the long run, state socialism, and if we wish to forego profits we must look forward to the same kind of existence as the people of Germany and Russia have to-day, where every man does what he is told whether he likes it or not.

I said a moment ago that I had no apologies to make for speaking of profits. I will go even further than that. I believe the industry has too long been pussy footing in fear of offending politicians, radicals and those who may temporarily be in power. If we believe in anything we should not be afraid to stand up and defend it. I believe in private industry, in free enterprise, and the profit motive, and I am willing to stand up and defend these principles before all comers. I think that it is a very healthy sign, not only for American industry, but for the American system and the American people as well, that the leaders of industry are beginning to get over their fear of being unpopular and are defending their acts and laying down a definite programme for the betterment, not only of industry but of society as a whole.

FIRST PROBLEM IS VOLUME OF SALES AT A PROFIT

Having got this little sermon on politics or economics, as you may choose to call it, off our chests, let us now proceed to a more critical examination of the detailed problems of the general manager. His first problem is to be sure that there will be a sufficient volume of sales of his company's product at such a margin of profit as to enable him to buy the raw materials necessary to make the product and to meet the pay roll of the men who fabricate this raw material into finished product. He is not a free agent in determining what he shall charge for his product. It is a theory taught in some text-books that the selling price should be the cost of production, including a reasonable amount for burden or overhead, plus a desired percentage of profit. This would be fine if he were permitted so to operate. As a matter of fact, the average manufacturer has little or nothing to say about what his prices shall be. They are fixed by the general market price of his produce, or in other words, by his competitors. If he cannot manufacture at a cost that will, after the proper amounts for depreciation and all the other overhead charges have been set aside, permit him to have something over with which to pay dividends to his stockholders and to provide for a surplus for plant expansion and the inevitable rainy day, he may do one of two things: First, he may set the price of his product at a point that will, on paper, yield him a profit, which price will be higher than that of his competitors. In such an event he soon will make no sales and then he will have no income with which to meet either pay roll or dividends. At this point he will join the ranks of the unemployed. The second course that is open to him is to make a drastic revision in his manufacturing methods and possibly in the design of his product so that he can then manufacture at a cost that will enable him to earn a profit.

WHAT IS A BUDGET?

What is a budget? It is simply a breakdown under certain well-recognised heads of the expected income in a given period, usually a year, and of the expenses, also broken down into an appropriate classification, that will be incurred in running the business. The income in the ordinary manufacturing concern will result almost entirely from sales. The general manager will call on the head of the sales department at the budget-making period, usually a couple of months before the beginning of the fiscal year, to give him an estimate of the volume of sales that reasonably may be expected in the next year. The sales manager, through his close contact with the customers and through his knowledge of the market from the salesmen's reports and from other sources, usually can forecast, within ten per cent. one way or the other, the number of units of each type of product that he expects to sell during the coming year. These quantities multiplied by the unit sales price give the total dollar income that the general manager can count upon. But the sales manager must do more than furnish figures of total volume. He must show the fluctuation in sales volume from month to month so that the general manager will know what his cash requirements will be at any period of the year to meet pay rolls, purchase raw material and meet all the other expenses that go into the running of a business.

Budgeting is simply looking facts in the face. Facts sometimes are disagreeable things, but in business it is far more disagreeable in the end to ignore the facts and substitute wishful thinking. That way lies bankruptcy. The budget gives to the general manager a picture of the business as it will go along from month to month throughout the year and enables him to lay out his course accordingly. Many managers and most accountants regard the budget as sacred, once set up, never to be changed. Regarded in this manner, the budget is anything but a helpful tool. In fact, it may become a drag on any business. The clear-thinking manager regards his budget principally as a yardstick by which to measure his performance at a given time. The budget should be flexible and subject to revision whenever conditions change.

The budget is not a pretty picture to look at and admire; it is a tool to be used, and the method of using it is to check performance against the budget figures. This usually is the duty of the chief financial officer of the company, in large organisations the comptroller, and in small ones the treasurer. Every month the financial officer should collect his costs, classified according to the budget set-up. Where the costs show in excess of the budget allowances he should immediately institute investigation with the department heads concerned to ascertain why expenditures were higher than those contemplated. If the operation indicates that an error has been made in the budget set-up and the excess expenditure will continue from month to month, then the budget should be revised, or steps taken so to change operations as to bring expenditures within the limit. On the other hand, if expenditures in a given classification are lower than the budget figures, it may indicate that the allowance made for a certain purpose is too great, and the budget should be revised accordingly. The practical effect of this is to release funds that have been allocated to one purpose where they are not needed for use for some other purpose where they may be necessary. For instance, the over-expenditure in one department may be counterbalanced by the under-expenditure in another without any increase in the total expenditures. Where the financial officer can make the corrections in operations simply by calling the attention of the involved department head to his departure from the programme, the general manager has nothing to think about. On the other hand, if the comptroller cannot resolve the difficulty himself, the matter then is one for the general manager's attention. That is, the general manager deals only with problems which no one else can handle.

PRODUCE DESIGN AND PRODUCTION METHODS DEMAND ATTENTION

The general manager is thinking all the time, in connection with his cost-reduction programme, of the design of the company's product and of the methods that the shop is using in manufacturing. Is the material entering into the product the best material for its purpose? If so, can it be bought at a price that will represent the greatest economy? Is there another material that will serve the purpose just as well without any sacrifice of mechanical excellence, and yet one that will cost less? Is a given piece so designed that it must be machined in a large and complicated machine like a horizontal boring, drilling and milling machine which carries a heavy burden rate, or can it be designed so that it can be machined in a drill press which carries a burden rate of less than half of that of the heavy horizontal! Here is a series of holes to be drilled in a certain surface. The shop is laboriously laying them out with a scale, dividers and centre punch. Is there not a simple jig that can be designed and built for a few dollars that will entirely eliminate the lay-out operation and which will pay for itself on the first job? How are the shop machines as regards accuracy? Are the foremen looking after their maintenance so that work, when it comes from them, does not require expensive correction and refitting? Will a special tool here enable one operation to be performed where two are now the usual practice?

SALES POLICY IS IMPORTANT TO SUCCESS

Another thing that the general manager thinks long and earnestly about is sales and sales policy. One of the questions that arises in his mind aside from how much the volume of sales will be in a given year or period is: What is the best method of selling, through agents or jobbers or by using salesmen, otherwise known as direct selling? The financial set-up of the different methods is not the only factor that must be considered. Sales customs, the convenience of customers, the ability to make prompt deliveries, all have a bearing on the choice of sales methods. When the manufacturer sets up his own sales force and sells direct he has the advantage of absolutely dictating his company's sales policies and of selecting his customers. On the other hand, he has to bear the burden of sales expense which includes salesmen's salaries and commissions and travelling expenses. These expenses may be reduced greatly if he sells through jobbers or agents. However, he will have to pay more or less greater commissions, which may or may not exceed in volume the cost of his own sales organisation. No set rule can be laid down as to which of the several methods of sales is the best. Each decision must be made on the merits of the case at hand. In the company with which I am connected two different products are manufactured which are best sold by two different methods. Heavy machine tools are sold by direct salesmen, and small toolroom grinders are sold through agents. Certain other products might well be handled both by agents and by direct selling, or by some other combination of sales methods.

MANAGER CANNOT OVERLOOK ADVERTISING POLICY

In close connection with sales problems is the question of advertising. Some general managers think advertising is a needless luxury and chart their course accordingly. In a well-established business with a reputation for its product built up over a period of years, the momentum of the business will in prosperous times perhaps carry the business for a considerable period. In the long run, however, the concern that drops its advertising will drop a large percentage of its sales volume. This has happened so many times that it can almost be accepted as an axiom of business. Here again is something for the general manager to think about. What kind of advertising is best for his particular business? Should it be trade-paper advertising, daily-newspaper advertising, circular letters, catalogues, fliers for envelope stuffers of one kind or another sent out with the regular mail? Radio, also, is another means of advertising, which for certain lines of business is exceedingly effective. Advertising, though a very necessary part of modern business, is a highly specialised profession, and the general manager who attempts to lay out his advertising programme without professional advice is just as foolish as the general manager who attempts to design the mechanical product of his company without engineering training. So another thing the general manager

* Excerpts from an address delivered to engineering students of the senior class, Sibley College, Cornell University, Ithaca, New York, February 17th, 1940.

† General Manager, William Sellers and Co., Inc., Philadelphia, Pa.

thinks about is what kind of an advertising agent he shall engage, and how much he shall pay him, and how much he can afford to spend on advertising. A company can throw away a vast amount of sales by an insufficient advertising appropriation. On the other hand, it can go broke very quickly by an injudicious expenditure for publicity.

Labour Relations

The greatest asset that any company can have is the skill of its working people. Andrew Carnegie once said that you could destroy his capital, burn down his mills, and otherwise wreck his business, but leave his organisation intact and in five years he would have fully recovered his position. The wise general manager is thinking all the time about how to conserve the skill of his trained employees. Not only is he constantly seeing to it that working conditions are right in the factory, but he is making sure that his wage scales are such that a man is a little better off in his plant than in any other plant employing the same character of help in his vicinity. I do not mean by this that any maudlin sympathy need be wasted or that the management must pry into the private lives of its help.

To the average employee the general manager is the company. If the general manager is square, the employee will think that the company is square. If he is easy going, seeking to be a good fellow, then the company will be regarded as an easy mark and its efficiency as a producing organisation will be low. So the general manager must have constantly in mind how his actions are going to react on the working force.

Let me emphasise once more the simple recipe for obtaining these results. Know exactly what to do. Know how it is to be done. See that your men know how. Insist on their doing it. Reward them for accomplishment, and discipline them for failure.

Rigid adherence with this programme will cause labour relations to cease being a problem. Human beings, taking them by and large, respond alike to the same kind of treatment. It makes no difference whether a man belongs to a labour union or does not belong to one. He is entitled to a square deal. The fact that a man thinks it to his best interest to join a labour union should not have any bearing on his treatment by management. He should be free to join or not to join just as he pleases. If management is square in its dealings with its men there will be less incentive for them to become unionised than if it tries to exploit them or to pay lower wages than is their fair due, or to work them longer hours than is good for them, or do any one of a host of things of which management has been guilty in the past. I have said publicly many times and I repeat it here, that most of the ills that have beset industry both at the hands of government and at the hands of organised labour are management's own fault. I hold no brief either for union or non-union labour. I have dealt with both. I have found that a willingness to meet the men half way or a little more than half way has always brought a like response from the men, whether they were acting as individuals, as a committee from a group of unorganised employees, or as a shop committee accompanied by the business agent of a trade union. There is no difficulty in dealing with organised or unorganised labour so long as you are willing to be square with them.

The Real Job is to Make Profits

The foregoing are just a few of the problems that come across the general manager's desk every day. There are many minor problems such as the adjustment of differences of opinion between department heads, decisions as to whether this or that policy is the best in a given case, whether or not the time is opportune to redesign the line or to design new products, listening to appeals from disciplinary action on the part of a supervisor down the line, and such other things as go to make up the day's work. But all these things are related one way or another to the real point of the general manager's job, as was pointed out previously, namely, how to make profits and to make more profits to the end that everybody shall benefit thereby, stockholder, management, employees and the public.

South African Broadcasting Equipment

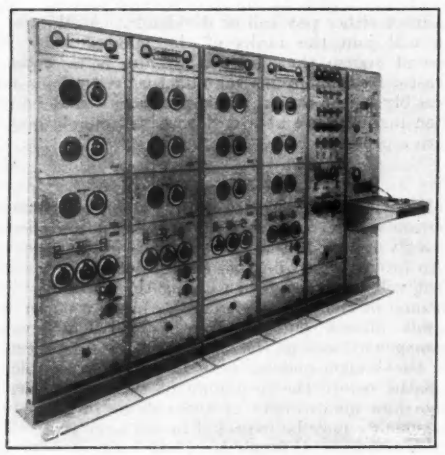
From the broadcasting station Panorama, a few miles west of Johannesburg, programmes of every kind are re-broadcast from the pick of Europe's stations and re-diffused throughout the whole of South Africa. The aerial system is a rhomboid arrangement of three aerials placed so that (1) is separated from (2) by 1250ft., (2) from (3) by 1240ft., and (1) from (3) by 2250ft. At present the aerials are directional on Central and Western Europe, but it is intended that at a later date additional aerials shall be set up to allow of reception from all parts of the world. While the present scheme is mainly intended for picking up signals on wavebands between 13 m. and 30 m., it also operates effectively on the 49 m. band; but beyond this point reception cannot be maintained at peak efficiency.

G.E.C. radio receivers and the associated gear are completely housed and mounted in eight racks, each 5ft. 6in. by 19in. wide. Rack 1 houses the aerial coupling board, racks 2 to 5 the four receivers, and rack 6 holds the diversity locking equipment. In rack 7 is housed the line and monitor amplifier equipment, while rack 8 is used for mounting the telephone apparatus. Flexible connectors on the aerial coupling board enable any aerial to be linked with any of the receivers.

Each of the receivers is an eight-valve superhet unit built by the General Electric Company, Ltd., for diversity reception. Amongst the special features called for in the design was the supply of H.T. and L.T. current from accumulators to avoid risk of noise from background. Each circuit in each receiver is individually tuned to maintain full efficiency. As opposed to the single tuning circuit of the ordinary home receiver, six circuits have to be tuned before reception from any station can be obtained, three being used for L.F. and three for R.F. tuning, the former being adjusted only in tuning the first station and subsequently left at the right setting then obtained.

Automatic volume control voltage is obtained from a valve which operates with its anode at earth potential and its cathode at minus 100 volts. The voltage developed across the anode load resistor of this valve is used to control the variable amplification valves. Hence, the stronger the signal, the greater the negative value of the voltage developed.

As an indication of the performance of the automatic volume control circuits, there is a 9 db change



CONTROL PANEL FOR RADIO RECEIVERS

in output for 60 db change in input above zero level, which is 10 microvolts. When receivers are coupled in diversity through the diversity locking equipment, *i.e.*, when the outputs are coupled through a mixer unit and their automatic volume control lines bonded, the receiver which has injected into it the greatest signal will take charge of the total output, for the receiver obtaining the greatest signal will bias the other receivers back so as to make them almost, or possibly entirely, inoperative. As soon as the strongest signal on aerial 1, for example, fades, aerials 2 or 3 may be in the strongest signal field, and the receiver coupled to whichever is the stronger of these will take control. Hence, the total output is being supplied to all receivers in their turn as they receive the strongest incoming signal.

It is naturally possible to couple the output of two, three, or four receivers as desired or to extract the outputs from each receiver separately. Precautions are taken to ensure that the outputs are coupled in phase, so that cancellation noticeable in the bass frequencies will not occur. Should it be desired to cut off the extreme high frequencies of the audio output, the line and monitor amplifier and equaliser is of value. The telephone line equipment transmits the modulated signal to the distributing studio.

Experience has shown that if the aerials are separated by 1000ft. or more, the signal they receive from a distant short-wave transmitter will fade on rare occasions on all three such aerials simultaneously. Hence it is not economically advisable to use four or more receivers in diversity as the reduction in fading per receiver added in excess of a total of three becomes very small. A fourth receiver is, however, used in order that a spare may be available for substitution in case of failure, or for use as a standby. Selective fading, *i.e.*, the type of fading which is accompanied by severe distortion, is not diminished by diversity working; in other words, diversity only aids in the elimination of straightforward fading.

Housed in an outroom the generator equipment is electrostatically shielded to prevent any radiation of interfering signals. The generator set is a petrol-electric unit developing 3½ kW at 220 volts, 50 cycles. As soon as a load in excess of 60 watts is demanded it starts up automatically from a storage battery and continues to run until the load is removed.

For low-tension charging the equipment consists of two mercury vapour rectifiers capable of developing a full-wave rectified current of 50 amperes. The charger for the high-tension supply consists of a mercury vapour full-wave rectifier capable of charging the complete high-tension battery at 5 amperes. For the 6-volt supply the battery power is obtained from two batteries of nine cells, each connected in series-parallel, and each cell having a capacity of 320 ampere hours. By means of switching arrangements it is possible to have one set of batteries in use while the other is on charge. For the high-tension supply use is made of thirty-three thirteen-plate, 6-volt motor-car batteries, with a capacity of approximately 60 ampere hours. If it is desired to discharge the high-tension cells more rapidly than usual, or if it is necessary to shut down the generating equipment at night, the house lighting is transferred to these high-tension cells.

For earthing use is made of 72 square feet of copper plate in the form of a sheet 6ft. wide buried on end, and to maintain efficiency the earth surrounding the plate is regularly watered. A bore-hole and windmill are situated on the property, and living quarters with all modern conveniences are provided for one engineer. Receiving and auxiliary apparatus was supplied by the G.E.C., of Magnet House, Kingsway, W.C.2.

Anti-Glare Measures at Foundries

The British Cast Iron Research Association makes the following announcement:—

Regulations under the Civil Defence Act, 1939, compel all works creating glare to screen this so that no glare is visible during black-out hours. Memoranda issued to all foundries in December, 1939, by the Ministry of Home Security and in April, 1940, by the British Cast Iron Research Association gave the procedure to be adopted in securing approval of anti-glare schemes in order to obtain Treasury grant. All anti-glare schemes on which Treasury grant is to be claimed must be submitted for approval by July 31st, 1940. In fixing this date the Ministry of Home Security, with the concurrence of the Anti-Glare Committee of the British Cast Iron Research Association, believe that schemes can be completed before the winter without causing hardship to the firms concerned.

It is understood that the Ministry of Home Security does not contemplate that exemptions from the anti-glare provisions of the Lighting (Restrictions) Order will be granted on the same basis during next winter and circumstances may compel the withdrawal of the exemptions still in operation.

All foundries requiring or expecting to operate cupola or other foundry furnaces, or otherwise creating glare, during the hours of darkness next winter must therefore install screening in order to prevent glare. Those firms wishing to obtain Treasury grant towards the expenses incurred must submit the scheme for approval by the Anti-Glare Committee of the British Cast Iron Research Association before July 31st, 1940. This applies to all ironfoundries, whether they do or do not employ more than fifty persons.

Firms who have not yet decided on the type of screening to adopt for preventing glare from the top of cupola furnaces may obtain advice on this subject from a new publication now obtainable from the British Cast Iron Research Association, 21, St. Paul's Square, Birmingham, 3, Special Publication No. 6, Anti-Glare Equipment for Cupola Furnaces, price 2s. 6d. post free. This report describes various types of equipment which have been developed for screening glare from the top of cupola furnaces, and supersedes the sections on anti-glare screening of the earlier Special Publication No. 4, A.R.P. for Cupola Furnaces.

In submitting a scheme for approval by the date fixed the procedure outlined in the memorandum issued by this Association in April last must be followed. It will not, however, be essential in the first instance to submit final drawings of the scheme in order to secure approval. A rough sketch of the equipment proposed or installed, or reference to one of the schemes described in the Association's Special Publication No. 6, mentioned above, will suffice. It will, however, be necessary to give an estimate of the cost of equipment, together with details of the quantities of material required, thickness of sheets, &c. Authorisation to purchase steel for anti-glare measures must now be obtained from the Ministry of Home Security, through the British Cast Iron Research Association, on the special form which was enclosed with the memorandum issued in April, 1940. Further copies of this form may be obtained from the Association on request.

The Institution of Gas Engineers.—In view of recent developments in the international situation and the consequent inability of responsible officials to leave their posts at the present time, the seventy-seventh annual general meeting of the Institution of Gas Engineers, which was to have been held in London on June 4th and 5th, 1940, has been postponed to a date to be decided later. The contributed papers which were to have been presented at the meeting will be published.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

New Export Prices

For some time past the British steel makers have been dissatisfied with the range of export prices. Not that this has affected them to any great extent, since they have had small opportunity of indulging in export trade owing to the excessive home demand; but it was, to say the least, irritating to know that the world prices of iron and steel were well above the rates which they had agreed amongst themselves to charge for British material. The export drive had less influence upon the iron and steel industry than upon many others, since it was obvious from the commencement that the part which the steel industry could play in the drive would be to supply materials to the home manufacturers of exportable products. It was clearly desirable that at a time when home trade requirements for so many articles was at such a high level, the export drive must be concentrated as much as possible upon the more highly finished, and therefore expensive, articles. At the same time, the Governmental iron and steel requirements of some of our Dominions and Colonies were considerably increased by the necessity of making war preparations, and these had to be supplied. Objections would naturally have been raised by those Empire Governments had the British prices been unduly advanced, so that there was a strong case for keeping values down. The final decision to advance the quotations by 5s. to 7s. 6d. scarcely met the wishes of many of the steel makers, and certainly does not bring British steel export quotations into line with the world prices as they existed until recently. The overrunning by the Germans of Belgium and Luxemburg has, of course, had a serious repercussion upon the world market, since several million tons of steel annually were normally sent abroad by these two countries. The squeeze in the world markets will not be so serious in present conditions as in 1914–1918, because several countries have in the intervening period erected iron and steel works of their own. It will, however, raise difficult problems in quite a number of countries in the Far East and to a certain extent in South America. The United States industry will probably reap the chief benefit and already production in that country is rising. The new British export quotations are as follows, f.o.b.:—Plates, ¾in. and up, £12 10s.; sheets, ½in. and under, £13 5s.; sheets, ⅜in., £15 7s. 6d.; chequered plates, ¼in. and up, £14 10s.; rounds and squares, 3in. and over, £13 10s.; angles and joists, £12 10s.; boiler plates, £14.

The Pig Iron Market

Conditions in the pig iron market show no appreciable change. The new munitions drive has added to the pressure for supplies, but so far as can be ascertained the Control has been able by careful distribution to maintain deliveries. It is interesting to note that the demand for foundry iron shows definite signs of expansion. This is due to the improved inquiry for high-phosphoric grades as a result of more of the light castings makers being put upon Government work. There does not appear to be any scarcity of this material, although the number of furnaces employed in its production has declined during the last few months owing to the slack demand from the light castings works and the increase in the number of furnaces making basic iron. The call for low-phosphoric foundry iron continues insistent and considerable quantities are passing into consumption at the engineering foundries, the motor vehicle manufacturers and to firms engaged upon the production of various kinds of machinery. It is expected that as the munitions drive develops the pressure to obtain supplies of foundry iron of all descriptions will grow, and some consumers envisage the possibility of a stringency. The Control, however, is averse to the accumulation of stocks by users, and those who hold reserves of this character are expected to utilise them before applying for new material. Whilst the demand from the consuming industries for foundry iron is expanding, in others it has been slightly curtailed by the improvement in the flow of cast iron scrap. Supplies of basic pig iron appear to have improved somewhat and production has increased of late, whilst the imports have helped the position. The deliveries of scrap to the steel works have been on a more satisfactory scale than for some time, and this has to some extent assisted in easing the basic pig iron situation. Supplies of ore have been reaching this country on a rather heavy scale recently and have enabled plant to be worked with greater regularity. There has been no slackening in the strong request for hematite iron. Sheffield and the Midlands in particular are taking large tonnages and although some stocks remain in the makers' hands these are being used up rather rapidly. The furnaces engaged upon the production of this description are operating at high pressure, but are receiving good supplies of ore and coke.

The North-East Coast and Yorkshire

Conditions on the North-East Coast show little change. Previous to the present munitions drive the works had been operating at as near to capacity as they possibly could and all available plant had been in use. The decision to keep machinery in employment seven days a week on a twenty-four hour day has made a noticeable increase in production, which had previously been at a very high level. The demand for all classes of steel is even more pressing than during the past few months, and every effort is being made to meet consumers' requirements. It is doubtful, now, if any order would be accepted unless for war purposes. With the shipyards working at high pressure their requirements are naturally on an extensive scale and astonishingly large tonnages are being absorbed week by week. Aerodromes in various parts of the country, new factories and extensions to existing works are being pressed forward and the demand for all classes of structural steel is insatiable. The acceleration of the munitions production has led to the development of a larger demand for special and alloy steels, which are being produced on a considerable scale. The semi-finished steel position, which some little while ago gave rise to anxiety, appears to be well in hand at the moment, in spite of the loss of the Belgian and Luxemburg works, and the re-rollers are able to maintain full operations. This is principally due to the increased production of our own works plus considerable imports. There may be some stringency in the supply of this material in the future, whilst arrangements are being made to secure deliveries from other countries, but there is no doubt that these supplies will be provided. The Yorkshire steel industry is fully engaged upon the production of steel for armaments. The quantities of basic steel produced by the Sheffield works is said to have reached record proportions, although naturally no statistics will be available for the duration of the war. High-carbon steel billets have been in much greater demand than recently and the works are not abreast of their deliveries. The munitions drive has resulted in a fresh call for aircraft steel, whilst other descriptions of munitions are taking up heavy quantities of alloy and high-speed steels.

Scotland and the North

The activity at the Scottish steel works, great as it has been, has increased since the demand for larger outputs of steel for munitions purposes. The steel makers' order books are already congested and they carry fresh contracts which will keep the works busy for months. Little of the steel now being turned out is for anything other than war purposes, and for the time being the makers are concentrating upon increasing their production in response to the appeal by the Government. Sectional steel of all sizes is required in huge tonnages, as there are still a number of Government factories being erected which will need large quantities. Aerodromes are being built and many works are extending their premises. All this calls for unprecedented tonnages of joists and sections, and although some of the constructional engineers are finding it difficult to get their full requirements, generally speaking this trade is well catered for by the Control. The shipbuilding industry on the Clyde is also absorbing immense supplies of steel in various forms. A very large tonnage of plates is passing to this industry and it is now difficult to place an order except for far distant delivery. The marine engineers are busy and are absorbing large quantities of steel, whilst there is a strong and to some extent unsatisfied demand for plates from the tank and boilermakers and the wagon builders. The tube mills have been busy almost from the beginning of the war, and lately have had to increase their efforts to meet a continual demand for all classes of their products. The re-rolling industry in Scotland has been well provided with semis and the output of the works has been well maintained, supplies of imported semis having enabled them to produce at practically full capacity. In the Lancashire district the steel makers are meeting with a persistent inquiry. The constructional and general engineers continue to absorb steel of all descriptions at a record rate. The demand for special and alloy steels has also expanded considerably since the commencement of the munitions drive. There is an exceptionally heavy call for steel bars of all sizes, and particularly for the larger diameters. Ferro-concrete bars have been much in demand during the past week or two. The works producing special steel used in aircraft production are kept well employed and there is likely to be a demand for this class of material for a long time. On the North-West Coast the steel works are operating at capacity and are turning out large quantities of railway material, strip, and steel for munitions.

Current Business

British Timken, Ltd., have acquired control of the Fischer Bearings Company, Ltd., of Wolverhampton, which began production in this country in 1936, having been founded by the German concern of Kugelfischer A.G. The company occupies a substantial portion of the old Sunbeam car works at Wolverhampton and employs a large number of men on the production of ball bearings. British Timken, Ltd., intend to concentrate the manufacture of ball bearings at the Wolverhampton works, which will provide much-needed room at their Birmingham works for the expansion of tapered roller bearing production. Norman Bell and Co. (Pty.), Ltd., of Brisbane, have been appointed agents in Queensland, Australia, for J. H. Fenner and Co., Ltd., power transmission engineers, Hull. It has been decided by the Glasgow Corporation that a supply of coke oven gas be accepted from William Dixon, Ltd., of not less than 28 million cubic feet per week. The manufacturers of rolling mill, hydraulic and blast-furnace plant and auxiliary machinery have formed an export group for the purpose of fostering and maintaining export trade, and to ensure supplies of raw material to fulfil export orders so far as is possible under present conditions. Manufacturers wishing to become members should write to the secretaries, Peat, Marwick, Mitchell and Co., 94, Petty France, Westminster, London, S.W.1. The Department of Overseas Trade announces that the following contracts are open for tender, local representation being essential:—South Africa, Municipality of East London: Cast iron pipes and fittings, sanitary fittings and earthenware (South Africa, July 10th). Johannesburg, Public Works Department: Electric body lift at the new police mortuary (Pretoria, July 11th).

Copper and Tin

The consumption of copper in Great Britain has bounded upwards under the impact of the accelerated munitions drive. It is, however, satisfactory to find that no consumers have been kept waiting for their raw material. The arrangements which have been made by the Control appear to be working smoothly, and no anxiety is felt regarding future supplies. Great Britain has bought 10,000 tons of wire bars in the United States, and is understood to be negotiating for a further 15,000 tons. The price paid is stated to be 11.37½c. f.a.s. Whether this copper is required for Great Britain or France has not been disclosed. The Allied Purchasing Commission is arranging purchases and therefore the destination of the copper might be either of those two countries. The world market has developed a weak tone, and although the allied purchases may do something to hold prices there is by no means a sound undertone in the market. The American domestic price is held at 11.50c. The unsettled state of Europe is the reason for the easier conditions in the export market, and it is reported that contracts which had been arranged for shipment to Italy and Russia have been cancelled. Naturally, the anxiety felt in the United States as to Italy's participation in the war on the side of Germany has slowed down business on export account in America. On the other hand, some orders have been placed by the neutrals left, including Sweden and Switzerland. India is also reported to have been a fairly good buyer. . . . Prices in the tin market have shown a tendency to advance. Conservative interests on the metal market regard the price as being at a somewhat dangerous level. Apparently the argument used by buyers is that the increase in the quota shows that there has been a substantial advance in the consumption of tin and that the price should automatically rise. Against this it is argued that the quota has been increased to meet an additional consumption and to keep the price down. No doubt to some extent the advance in quotations has been due to manipulation, but, on the other hand, the heavy purchases by the United States have helped to create a stronger feeling. It is expected, for instance, that the United States Government will buy further substantial quantities to create a big war reserve.

Lead and Spelter

So far as Great Britain is concerned the amount of lead available seems to be adequate, and regular and sufficient supplies are reaching consumers. There has been an expansion in consumption in this country owing to the munitions drive. The world market is firmer, although there has been no noticeable change in prices in the United States. According to statistics published in America, the stocks of refined lead there at the end of March totalled 64,326 short tons, compared with 62,949 tons at the end of February. On March 31st, 1939, the stocks were 109,965 tons. The reserves of antimonial lead on March 31st last totalled 10,366 tons, compared with 9709 tons in February. It has been suggested that the invasion of Holland and Belgium will curtail supplies of lead to France. It will make little difference to Great Britain, however, since ample supplies are available from Empire producers, and the French requirements could probably be met quite easily from the large Mexican production. At present it would appear that so many markets have been cut off from Mexico that the production there cannot now be fully utilised. The Germans have probably obtained a certain amount of lead from their invasions, but it is not believed that the tonnage is impressive, and whilst they have now in their hands a tremendous refining capacity they are cut off by the blockade from obtaining supplies of raw material. . . . The spelter market has developed considerable strength in the United States, where it is reported that large purchases have been made by the Allied Purchasing Commission. No doubt a considerable proportion of the metal purchased will be for France, whose normal sources of supply in Northern France and Belgium have been interrupted by the invasion. In addition to the Allied purchases, those neutrals who have not been overrun have been inquiring in the United States. India has also been a buyer. Another factor tending to increase the price is the demand from the United States Government as a result of their rearmament programme. The price has now advanced to 6.25c., East St. Louis. The British demand has expanded and is being met almost entirely from Empire sources. Consumers in this country are obtaining all the metal they want, but there have been instances of late where they have asked for lower grades of G.O.B. spelter, such as they formerly obtained from Belgium, but have had to take higher quality material. No doubt the stocks of Belgian spelter which existed in this country have now become exhausted. This makes no difference to consumers, except that they have to pay a slightly higher price, and it is not a real hardship.

Non-ferrous Metal Prices

The London Metal Exchange official statement for May discloses a sharp rise in the average prices for tin. This is largely the result of the precautionary buying which took place upon the news of the German invasion of Holland and Belgium on May 10th, which sent values up to the extent of about £15 per ton. The settlement price for May is £11 19s. 10d. above the average for April, the average cash quotation being £12 0s. 8d. higher, whilst for three months the average price in May is £13 11s. 8d. above the average for the previous month. The statement also gives the official maximum prices for copper, lead, and spelter as fixed by the Controller of Non-Ferrous Metals, as follows:—

STANDARD TIN ...	Cash (Mean) £264 5s. 9$\frac{5}{32}$d.	
	3 Months (Mean) £261 19s. 0$\frac{5}{32}$d.	
	Settlement (Mean) £264 3s. 8$\frac{5}{32}$d.	

The following prices for copper, lead, and spelter are the maximum prices fixed by the Controller of Non-Ferrous Metals:—

	£	s.	d.			
STANDARD COPPER ...	—					
Electrolytic Copper ...	62	0	0	delivered	buyers'	premises
Electrolytic Wire Bars...	62	0	0	,,	,,	,,
Best Selected Copper ...	60	10	0	,,	,,	,,
Lead—Good Soft Pig ...	25	0	0	,,	,,	,,
(Foreign)						(duty paid)
Spelter—G.O.B.	25	15	0	delivered	buyers'	premises
(Foreign)						(duty paid)

French Engineering Notes

(From our own Correspondent in Paris)

The Paris Trade Fair

Or the annual trade fairs in which machinery occupies a large place, the one at Lyons was held in April, the Paris Fair in May, and arrangements have been made for the Fair at Bordeaux in June. These gatherings offer the only means of exhibiting engineering and metallurgical products, and are consequently of value to the industry; but this year it was at first suggested that it would be prudent to cancel them altogether. Then the question of industrial interests and national dignity weighed the scale in favour of continuing the three leading fairs. The first one in Paris was held during the last war, and if Leipzig could carry on this year there appeared to be no reason why Paris, Lyons, and Bordeaux should admit inferiority in enterprise under the present difficult conditions. When manufacturers are all engaged more or less on armament work, and supplies of raw materials for export production are restricted to what is needed for the execution of orders, makers are inclined to disregard fairs in which they are unable to participate with credit to themselves. Machines required for national defence cannot be released for exhibition. So far as engineering products are concerned the Paris Fair partially failed to fulfil plans that were intended to help the organised effort to expand export trade. Notwithstanding the small number of exhibits in the machine tool section, their quality gave an indication of progress that has been made in the French industry. The manufacture of grinding machines, for example, was only begun in France a few years ago, and the exhibit of Gendron Frères, of Lyons, showed that machines for precision grinding have come to the front rank in this branch of machine tool production. Another departure was the increasing heavy plate construction of punching and shearing machines. In general and public works machinery there was the same falling-off in the number and importance of French exhibitors, which can only be explained by an inability to provide anything for exhibition, since French makers were always strongly represented in this section. American road-making machinery was mostly prominent, and of power shovels there were one British and one French. Of particular interest was the light thrown on the commercial relations between Britain and France as revealed by the larger number of British firms represented in this country. Agents must take up British goods if they would do business at all. By reason of sentiment and interest and even of necessity there is no discrimination between British and French engineering products. The resistance of French makers to imports of machines and other products that they are capable, normally, of manufacturing themselves has had to give way under pressure of the increasing war production effort. The Federation of British Industries was serving as intermediary in business transactions which are necessarily confined largely to whatever is required for national defence, and orders for goods which France is anxious to buy appear to exceed what British manufacturers are capable of executing.

Suction Gas Traction

As usual, the application of suction gas to road vehicles was a feature of the Paris Fair, although the propaganda in its favour that was carried on in previous years is no longer necessary now that the compulsory use of suction gas is being extended. Portable producers have been improved in many ways both for wood and charcoal, and on one of the cars gas from the generator passes into an apparatus called the "cyclone," which eliminates most of the dust by centrifugal action, and then circulates through the cooling tubes before entering the filter. A compressor delivers the gas to the engine through a small radiator to lower the temperature that has been raised by the compressor. The gas is compressed sufficiently in the induction pipe to ensure the cylinders being instantaneously filled with gas under moderate pressure. Portable plants are being improved both in efficiency and in providing facilities for cleaning. Since the compulsory use of national fuels, which practically means suction gas, was applied effectively at the beginning of the year to 10 per cent. of vehicles employed by owners for public services, there was an order that, as the entire production of heavy lorries had been monopolised for national defence, a certain number of them would be released for sale to private owners who would undertake to equip them to run on national fuels. Now another order has been issued to the effect that manufacturers and importers are required to equip a percentage of all the lorries of more than 2000 Kg. to run on charcoal suction gas or other national fuel. It is specified that a petrol tank may be fitted of not more than 10 litres capacity. This is intended to provide acceleration when necessary, give temporary boosting on difficult gradients, and allow of manœuvring in garages and on other occasions when it is inconvenient to start up the suction gas plant. The percentage of new lorries to be thus equipped by manufacturers will be determined every three months.

Working Hours

In view of the necessity of intensifying the war effort and increasing armament production to the extreme limit, all works and factories engaged wholly or partly on armament contracts are required to run the full twenty-four hours. The hours of workers have been increased to twelve a day. Holidays are suppressed, and a double rate of pay will be allowed in their place. Every man is thus working to the limit of his physical capacity. There is no complaining, for workers know that ultimate victory depends on them, and while four years ago they made an uncompromising fight for claims that were, for the most part, incorporated in the labour statute, they accept the conditions now imposed by the Government, knowing that after the war their legal rights will be restored to them. Special measures have also been taken to prevent possible acts of sabotage, for despite the virtual suppression of Communism its indirect influence is not yet completely extinguished.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

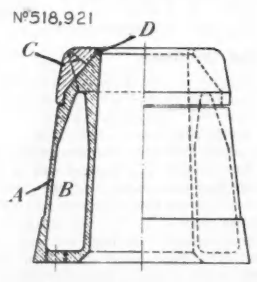
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

FURNACES

518,921. August 9th, 1938.—IMPROVEMENTS IN TUYERES Freyn Engineering Company, 310, South Michigan Avenue, City of Chicago, County of Cook, State of Illinois, United States of America.

The accompanying drawing is a view, partly in section, showing one form of tuyere embodying the invention. The body A is of a metal having a relatively high heat conductivity, such as copper, aluminium, or the like, and is cored out to provide

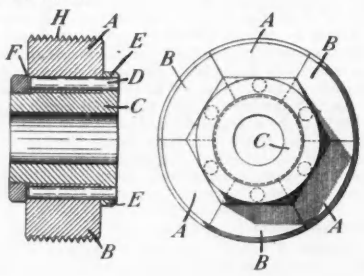


the annular water space B. It is armoured at its forward extremity by means of the nose C of a metal having a higher melting point and a lower heat conductivity than that of the body. The forward extremity of the tuyere body is provided with a massive nose portion at the tip of which is an annular shoulder D. In assembling, the armouring nose seats itself in intimate contact with the conical wall of the body nose portion, the shoulder D is then swedged outwardly against the flaring wall of the top of the nose, as shown, to hold it securely in position.—*March 12th*, 1940.

MACHINE TOOLS AND SHOP APPLIANCES

519,080. September 21st, 1938.—CRUSHING ROLLERS FOR FORMING THE OPERATIVE SURFACES OF GRINDING WHEELS, Coventry Gauge and Tool Company, Ltd., Fletchamstead, Coventry, Stanley Jaffa Harley, "Long Bend," Old Leamington Road, Stivichall, Coventry, and John Ernest Wainwright, 40, Berkeley Road, Coventry

The improved crushing roller is built up of a number of segments A, B, of hard and soft steel respectively arranged alternatively around and upon a hub C. The segments may be held in position about the hub in any suitable manner, as by

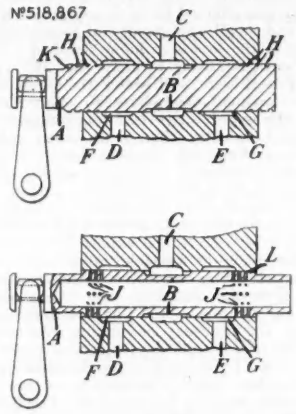


means of driving pegs D attached to a flange E of the hub and passing through holes in the several segments. Axial displacement of the segments is prevented by means of a nut F on the other end of the hub, the arrangement being such that when the nut is tightened up the segments are firmly clamped against the flange. When the segments are assembled on the hub, the periphery of the roller can be machined and ground to the required form and, when used for dressing grinding wheels used for grinding, screw threads, can be formed, as shown, with serrations or cutting edges H of screw thread form.—*March 15th*, 1940.

MISCELLANEOUS

518,867. July 15th, 1938.—HYDRAULIC PISTON TYPE CONTROL VALVES, John Maurice Towler, Wells House, Thruscross, Summerbridge, near Harrogate, Yorkshire, and Frank Hathorn Towler, of Dob Park, near Otley, Yorkshire.

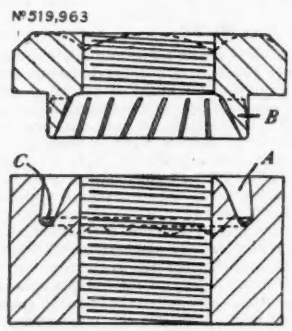
This invention relates to hydraulic piston type control valves of the packingless piston type in which fluid tightness is maintained by making the piston a very close sliding fit in the bore of the valve body. Its object is to provide a valve which will also control the rate of flow of liquid from each outer chamber to exhaust so that over a relatively long endwise movement of the piston valve such rate of flow will be increased gradually from a minimum rate of flow to a maximum. In both the examples illustrated the control valve consists of a body which has a close fluid-tight piston valve A. This piston is formed with a central portion B of reduced diameter, and is moved endwise by a lever. The bore forms three equidistant annular recesses. The central recess is intended to receive pressure liquid from a pump through the inlet C whilst the two outer recesses connect respectively through outlets D and E with opposite ends of a hydraulic cylinder or cylinders forming part of the hydraulic machinery to be controlled. The two outer recesses F and G also function in turn to receive the liquid exhausted. In the embodiment shown in the upper view exhaust liquid is permitted to escape from each outer recess through a channel formed by cutting a helical groove H in each outer end of the piston valve. The groove is preferably cut so that its depth increases gradually towards each end of the piston so that the rate of exhaust will increase proportionately as the convolutions of the groove become uncovered. In the lower view exhaust liquid is permitted to escape from each outer recess either through a series of small transverse holes J which break into a hole bored through the centre of the valve and open to exhaust either at one or both ends. In the drawings the piston valves are shown in the "off" position. Two outer recesses in the first example are closed to exhaust and in the second example are partially open to exhaust through one or more of the leading holes. If desired the first embodiment may also be modified by extending the helical grooves. As the piston is moved further towards either end the area of exhaust outlet to one outer recess will be gradually increased, whilst the exhaust outlet to the opposite outer recess will be shut as the groove or holes become covered by either bank K or L according to the direction of movement. As this movement is continued the central portion B of the valve will gradually overlap one or other of the outer recesses, so



that it acts as a transfer port to permit pressure fluid to pass from the central recess to the outer recess and so through its outlet to the cylinder of the hydraulic machine. When the piston valve is in either extreme position one outer recess will be fully open to exhaust by way of the helical groove or the series of small holes, whilst the opposite outer recess will be in full communication with the central recess. By varying the extent of endwise movement of the piston valve, it is thus possible correspondingly to vary the rate of exhaust from the cylinder or cylinders of the hydraulic machine.—*March 11th*, 1940.

519,963. October 25th, 1938.—LOCK-NUTS, Hercules John Demetriades, 3, Dumbreck Road, Glasgow, S.1, and Norman Charles Baird, 189, Broomloan Road, Glasgow, S.W.1.

The accompanying drawings show the components of a lock-nut according to the invention. An end face of one of the components is formed, round the bolt hole, with an annular recess or groove A of V-shape in cross section. The bottom of the groove may be rounded and merge into the inner wall



which slopes inwardly. An end face of the other component is formed, with an annular projection B of V-shaped cross section and adapted to be forced into the groove in the first component. When forced into the groove, the projection B is distorted into the undercut part of the groove so as to be locked against withdrawal. If desired and as shown, the projection may be formed with a number of fine saw cuts. Before the components are assembled a small soft metal ring C of U-section may be dropped into the groove and wedged between the projection and the bottom.—*April 10th*, 1940.

PERSONAL AND BUSINESS ANNOUNCEMENTS

GEORGE ELLISON, Ltd., advise us that as a war-time measure, it has been necessary for their Newcastle office to remove to a new address:—Victor Buildings, 15, New Bridge Street, Newcastle-on-Tyne, 2.

MR. WILLIAM THOMPSON, M.I. Chem. E., M.I. Weld. E., has been appointed chief engineer of Magnesium Metal Corporation, Swansea.

CATALOGUES

CROFTS, Ltd., Bradford.—Catalogue S 140 of standard power transmission appliances.

HERBERT MORRIS, Ltd., Loughborough.—Catalogue of worm-gear pulley blocks from ½ ton to 60 tons.

ALFRED HERBERT, Ltd., Coventry.—Catalogue No. 12 of small tools and machine shop accessories.

DAVIDSON AND CO., Ltd., Belfast.—Publication No. SF 310, illustrating and describing compressed air-driven fans.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London.—Catalogue of pole or wall mounting high and low-tension switchgear.

RANSOMES, SIMS AND JEFFERIES, Ltd., Orwell Works, Ipswich.—Booklet, entitled "History in Pictures," dealing with the development of trolleybuses.

HOUSEMAN AND THOMPSON, Ltd., Newcastle-upon-Tyne.—Booklet entitled "The Treatment of Cooling Water for Diesel, Oil, Gas, and Petrol Engines, Transformers, &c."

DAVY AND UNITED ENGINEERING COMPANY, Ltd., Sheffield.—Publication No. 90, describing the types of rolls manufactured by the subsidiary company, Davy and United Roll Foundry, Ltd., Billingham.